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SENSITIVITY OF COASTAL ENVIRONMENTS AND WILDLIFE TO SPILLED OIL

ALASKA

- SHELIKOF STRAIT REGION -

Daniel D. Domeracki, Larry C. Thebeau,
Charles D. Getter, James L. Sadd,
and Christopher H. Ruby

Research Planning Institute, Inc.
Miles O. Hayes, President
925 Gervais Street
Columbia, South Carolina 29201

- with contributions from -

Dave Maiero
Science Applications, Inc.
and
Dennis Lees
Dames and Moore

PREPARED FOR:

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ERRATA

Page 26, Figure 11; Caption should read:

Exposed rocky shore showing four distinct biological zones: (1) barnacle (Balanus ... zone. (2) blue mussel zone. (3) brown and red algae zone, and (4) barnacle (Balanus cariosus) zone.

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EXECUTIVE SUMMARY

This report is an explanatory text for a series of 40 maps which cover the Shelikof Strait region of southwest Alaska (Fig. 1). These maps delineate the sensitivity of coastal environments to oil spill impact. The classification system used, the Environmental Sensitivity Index (ESI), ranks coastal environments on a scale of 1 to 10 in increasing order of sensitivity (i.e. , 1 is least sensitive, and 10 is the most sensitive) . Biological considerations such as the location of bird colonies, seal haulouts, and shellfish areas are indicated on the maps.

Field work was carried out between 19 May and 10 June 1980. A shoreline assessment technique, called the <u>integrated zonal method</u>, was used to classify the coastal environments present in the study area. The technique included aerial reconnaissance of the shoreline, site-specific studies at 63 profile sites, and an extensive review of available literature. Using this information, ten different coastal environments were identified and assigned ESI numbers as listed below:

1) Exposed rocky headlands.
2) Wave-cut platforms.
3) Fine/medium-grained sand beaches.
4) Coarse-grained sand beaches.
5) Exposed tidal flats (low biomass).
6) Mixed sand and gravel beaches.

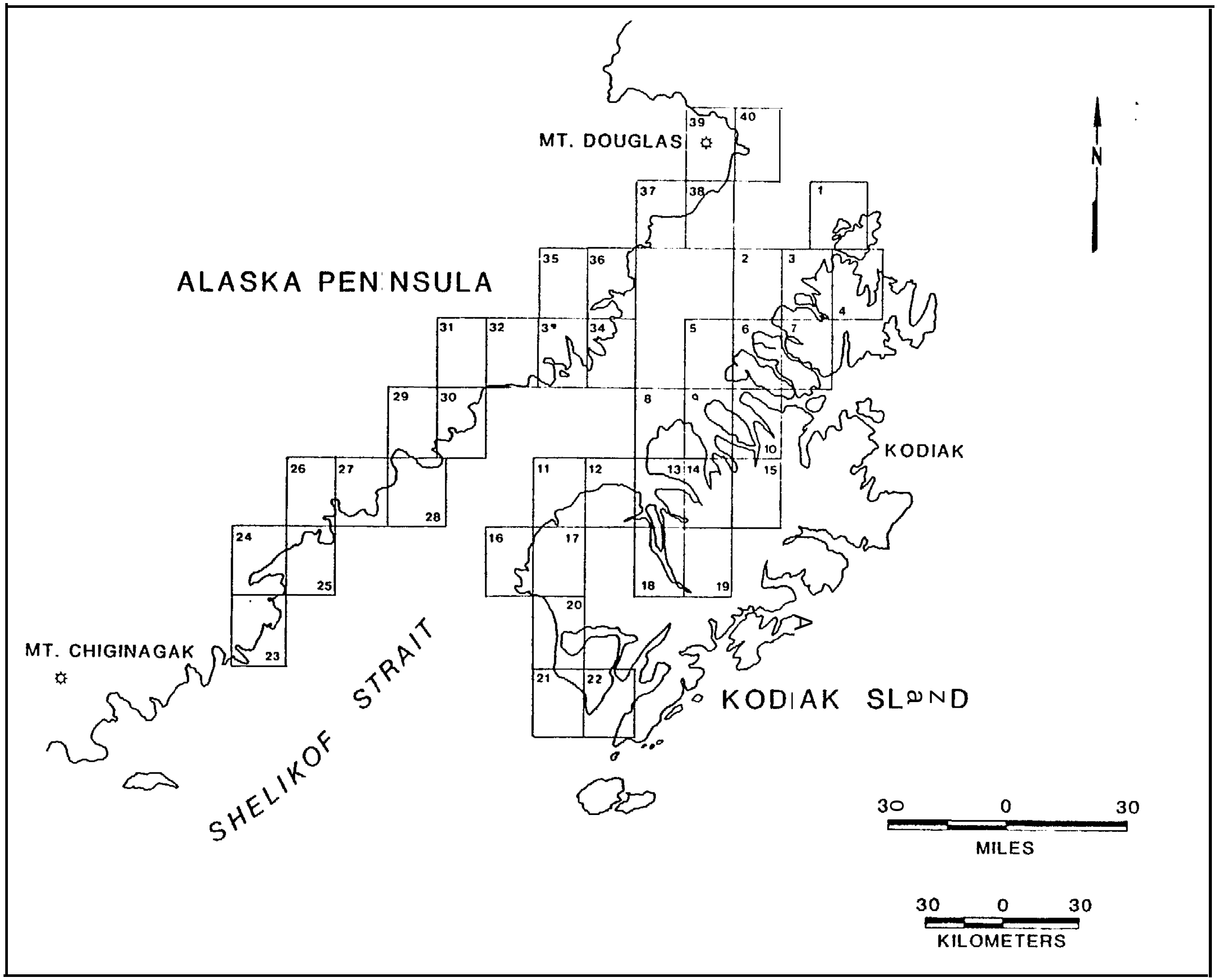

FIGURE 1. Map showing the location of each ESI map.

7) Gravel beaches.

7a) Exposed tidal flats (moderate biomass).

8) Sheltered rocky shores.

9) Sheltered tidal flats.

10) Marshes.

Basic strategies for spill response and protection are outlined briefly in the text. Of all the habitats present, salt marshes, sheltered tidal flats, and sheltered rocky shores are considered to be the most sensitive to long-term, oil-spill damage and should receive the highest priority for protection in the event of a spill. In contrast, exposed rocky shores (ESI=1, 2), which are quite common throughout the study area, would be cleaned rapidly by wave action and, therefore, would require only minor protection and cleanup considerations.

ACKNOWLEDGMENTS

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Dave Maiero of Science Applications, Inc., researched the socioeconomic information and made many contributions to its ultimate presentation on the ESI maps. Dennis Lees of Dames and Moore was a member of the field team and provided valuable insight to our assessment of the Alaskan shoreline. Also much of the information concerning subtidal habitats presented in this report was prepared by Mr. Lees.

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Erich Gundlach, Geoffrey Scott, James Sadd, and Dave Maiero carried out part of the mapping on the Alaskan Peninsula side of Shelikof Strait. Miles O. Hayes is acknowledged for project management, as well as organizational and editorial suggestions on this report.

INTRODUCTION

The state of Alaska is currently undergoing intensive environmental analysis as its coastal waters become increasingly desirable for offshore oil exploration. Offshore drilling, support facilities, and tanker traffic increase the possibility of open-water oil spills in this region, creating a need for a comprehensive oil-spill contingency plan.

In response to this need and under the support of the National Oceanic and Atmospheric Administration/Outer Continental Shelf Environmental Assessment Program (NOAA/OCSEAP), Research Planning Institute, Inc. (RPI) has mapped several thousand miles of Alaska shoreline over the past four years, using the Oil Spill Vulnerability Index (Gundlach and Hayes, 1978a) (Fig. 2). This index classifies coastal environments primarily in terms of geomorphic considerations, that is, the physical response of an environment to spilled oil. The Environmental Sensitivity Index (ESI) (Hayes et al., 1980) was developed to add biological and socioeconomic components to the geomorphic considerations.

The ESI was applied to the Shelikof Strait region of southwest Alaska to aid in the environmental assessment relative to outer continental shelf (OCS) Lease Sale No. 60 and in the preparation of oil-spill contingency planning. The index, developed from oil-spill case studies, field research, and extensive literature review, classifies

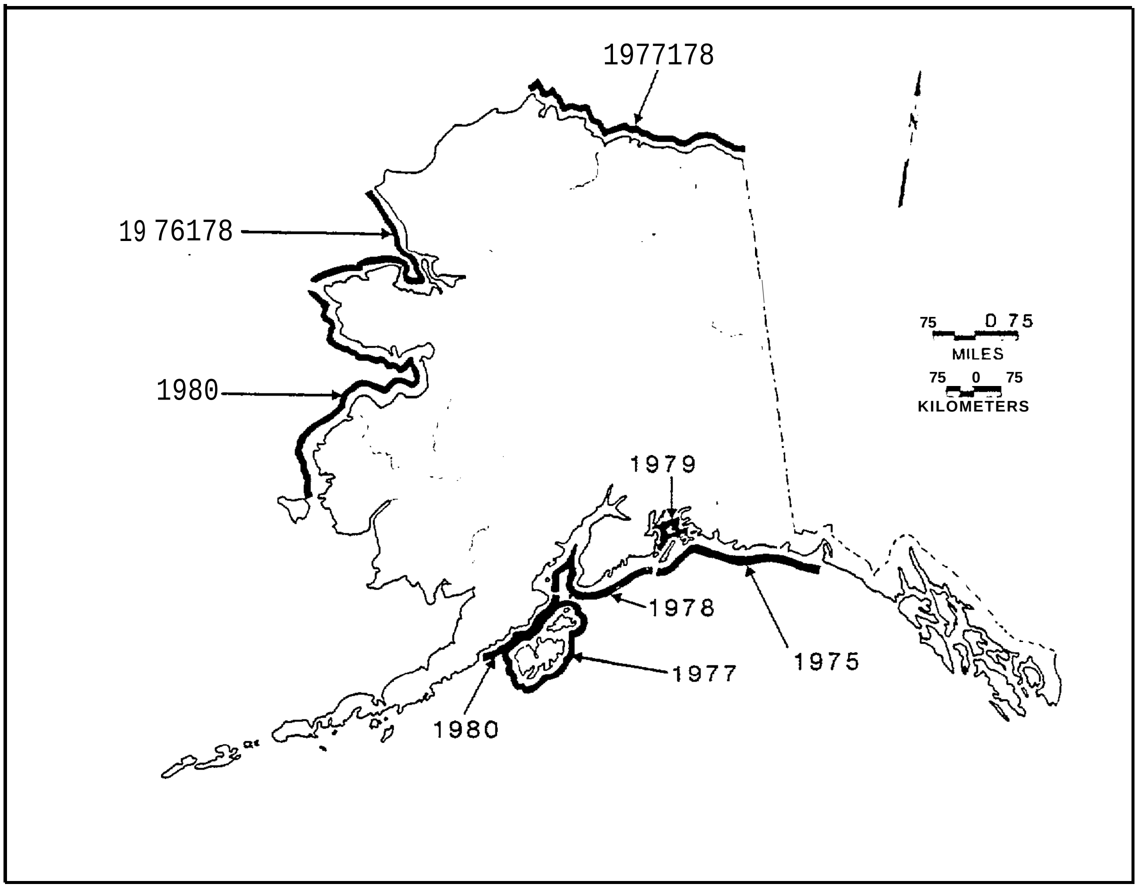

FIGURE 2. Map of Alaska indicating environmental mapping studies conducted by University of South Carolina and RPI personnel; M. O. Hayes, Principal Investigator.

coastal environments on a scale of 1 to 10 in order of their increasing sensitivity to spilled oil. This report provides a synthesis of study methods, the environments classified by the ESI, and suggestions for shoreline protection strategies. There is also a summary of geomorphic parameters, major biological resources, and socioeconomic considerations which describe their probable response to oiling. In total, 40 maps (1:63,360 scale; 15-minute quads) were prepared.

PHYSICAL SETTING

Geology

The Kodiak Archipelago and the Alaska Peninsula are part of one of the most tectonically dynamic regions of the world. The study area lies just northwest of a major plate boundary where dense oceanic crust (the Pacific Plate) is being rapidly subducted beneath lighter continental crust (the North American Plate). This tectonic regime results in the development of many large-scale, structural features which include:

a) A deep submarine trench (i.e., Aleutian Trench) .

b) A series of sediment-filled structural depressions or forearc basins (i.e., Shelikof Strait and the sedimentary basin on the shelf southeast of Kodiak Island).

c) Thrust-faulted bedrock wedges which extend above sea level (i.e., Kodiak Archipelago and the Alaska Peninsula).

d) An active volcanic arc (Alaska Peninsula and Aleutian Channel).

These features are oriented along the structural grain of the region, which trends northeast and is parallel to the Aleutian Trench Plate boundary. The study area consists of open folds and *en echelon* thrust faults with upthrown northern limbs. Many of the major tectonic features of the southwestern Alaska structural province are present in the study area, including the Bruin Bay and the Border Ranges Fault zones (Fig. 3; modified from Selkregg, 1974; Fig. 53a).

Subduction zone boundaries and island-arc regions are tectonically very active and are the loci of global seismicity. Rapid rates of uplift tend to create steep slopes and incised drainage patterns, resulting in rugged topography and immature shorelines. The tectonic activity of the region is characterized by such recent events as the 1964 Good Friday earthquake (Stanley, 1966), the volcanic eruptions at Katmai/Novarupta in 1912, and the eruptions of the Trident volcanoes in the 1950's and 1960's. These events were accompanied by landslides, ash falls, and vertical displacements of bedrock up to three meters (Stanley, 1966; Plafker and Kachadoorian, 1966).

The bedrock of the study area is an uplifted and deformed structural belt composed of marine metasedimentary and metavolcanic rocks, which are intruded by batholithic and volcanic rocks (Fig. 3). A thick basal sequence of metasediments is unconformably overlain by fine-grained sediments aging from the Mid-Jurassic to Tertiary. The entire complex was intruded by mineralized Tertiary batholiths. Large-scale, thrust faults brought older metasediments in contact with younger rocks. The Alaska Peninsula segment was then pierced by the Aleutian volcanic-arc complex. Major thrust faults on Kodiak (e.g., Uganik Thrust) are intercepted as boundaries separating older, subduction

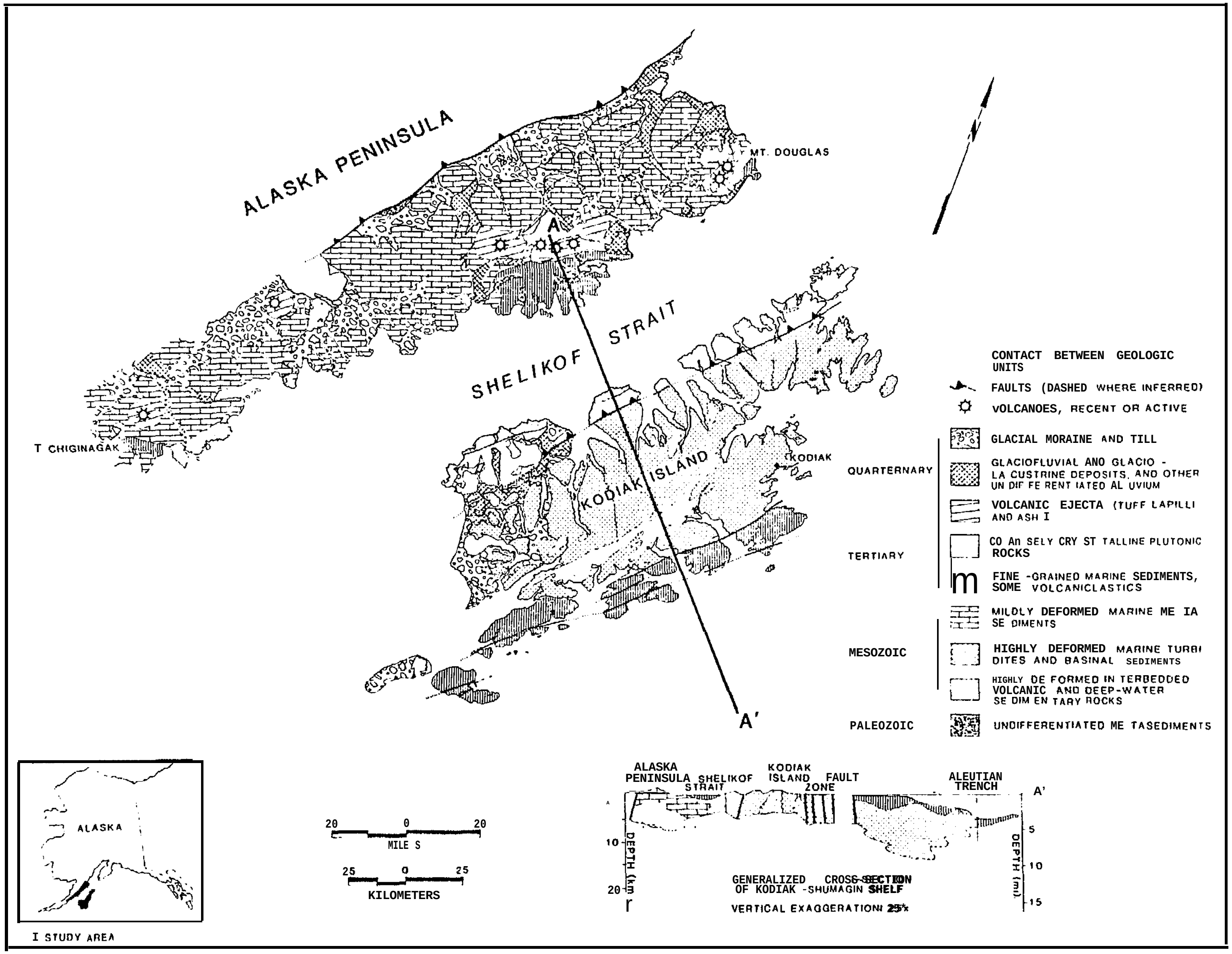

FIGURE 3. Geological base map of the study area (modified from Selkregg, 1974; Fig. 53a).

complexes and deep-sea metasediments from younger, basinal marine sediments. This seaward accretion continues today at the plate margin (Burk, 1965; Plafker, 1972; Connelly, 1978; Moore, 1978).

Lithologic Units

Eight major lithologic units are present in the study area. These include Paleozoic basement, stacked volcano sedimentary packages (i.e., Late Triassic Shuyak Formation, Early Jurassic Kodiak Islands Schist Terrain, Cretaceus Uyak Complex, Cape Current Terrain, and the Upper Cretaceus Kodiak Formation), and marine basal sediments (i.e. , Early to Mid-Tertiary Sitkalidak and Narrow Cape Formations).

The oldest rocks are a thick, Paleozoic metasedimentary sequence of gneiss, schist, slate, quartzite, and marble. This unit is present in isolated outcrops on the Alaska Peninsula north of the Bruin Bay Fault.

Unconformably overlying the Paleozoic basement on the Alaska Peninsula is a thick, Mid- to Late-Mesozoic, metasedimentary complex intruded by a large, Mid-Tertiary batholith.

The basal unit on Kodiak Island is the Shuyak Formation, an early Mesozoic, metavolcanic sequence with interbedded turbidites (Connelly, 1978). This is overlain by a highly deformed and metamorphosed volcanic and sedimentary unit derived from a Mid- to Late-Mesozoic, subduction complex (Moore, 1969; Carden, 1977; Carden et al., 1977) .

These rocks are intruded by a small, Jurassic hornblende diorite pluton (Connelly, 1978) .

The Kodiak Formation (Upper Cretaceus) makes up most of Kodiak Island. It is a deformed, marine turbidite sequence composed of coarse conglomerates, interbedded with arkosic wackestones (Moore, 1969) . This formation has been interpreted as a deep-sea, trench sequence deposited during subduction (Plafker, 1972; Moore, 1973a, b; Jones and Clark, 1973; Budnik, 1974) . Kodiak rocks were subsequently intruded by an Early Tertiary pluton which runs down the axis of Kodiak Island. Overlying the Kodiak Formation is the Early Tertiary Ghost Rocks Formation, composed primarily of wacke and argillite. This highly deformed unit is interpreted as a tectonic, melange wedge deposited during subduction.

The entire Mesozoic section is overlain by fine-grained, Tertiary marine sediments derived from erosion of the Alaska Range and Talkeetna Mountains to the northeast (Sitkalidak and Narrow Cape Formations; Moore, 1969).

Geomorphology

The coastline of the study area has youthful topographic features resulting from active tectonism and intense Quaternary glaciation. Long, narrow fjords and U-shaped valleys, separated by rocky headlands with wave-cut platforms and coarse-grained pocket beaches, are the predominant geomorphic features on exposed coasts. Mixed sand

and gravel beaches and sheltered rocky headlands fringe the fjord interiors. Sheltered tidal flats and marshes are present at the head of several fjords.

Topographically low areas are most commonly outwash plains with accumulations of unconsolidated glacial sediments covered by ash soils. High rates of uplift and rainfall coupled with locally steep slopes induce rapid erosion and landsliding. This material is reworked by marine processes to form long expanses of mixed sand and gravel beaches (e.g., southwestern Kodiak Island and the Puale Bay area of the Alaska Peninsula). Tertiary volcano-elastic sediments are exposed in an erosional shoreline in the Katmai River vicinity. Exposed erosional escarpments and pocket beaches are fronted by low-tide terraces composed of the reworked sediments. At the mouth of the Katmai River, a small delta-strand plain system is present fronting wide, sheltered tidal flats.

Shoreline sediments in exposed areas tend to be coarse-grained (gravel/boulder) with very little sand or mud, reflecting high-energy marine conditions (Fig. 4; from Sears and Zimmerman, 1977). Fine-grained sediments are common only in sheltered, back bay areas.

Physical Oceanography/Climate

The entire southwestern Alaska province experiences a maritime climate with heavy precipitation. Air temperature averages about 10°C (50°F) and ranges from -14°C to 22.2°C

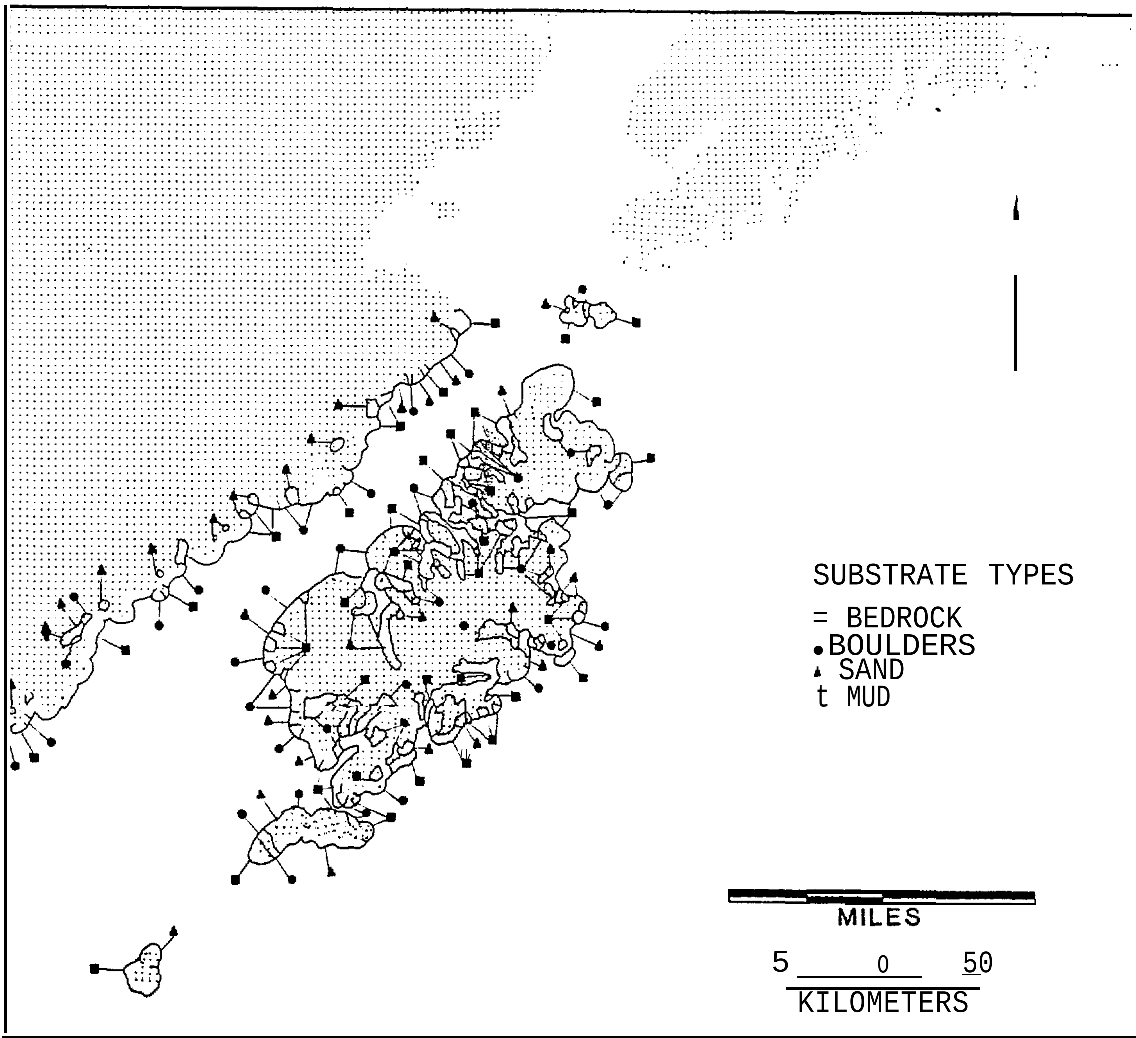

FIGURE 4. Map indicating the general distribution of substrate types throughout the study area (from Sears and Zimmerman, 1977).

(6°F to 72°F). Total annual precipitation is about 290 cm (114.3 in), 150 cm (58.5 in) falling as snow (AEIDC, NCC, 1977a; b). Wind and wave directions are predominantly westerly and northwesterly (Fig. 5), but vary seasonally. In general, winds blow from the east and south in the summer, and the north during the winter. Data on winds and waves are summarized in Appendix I. High velocity winds and large

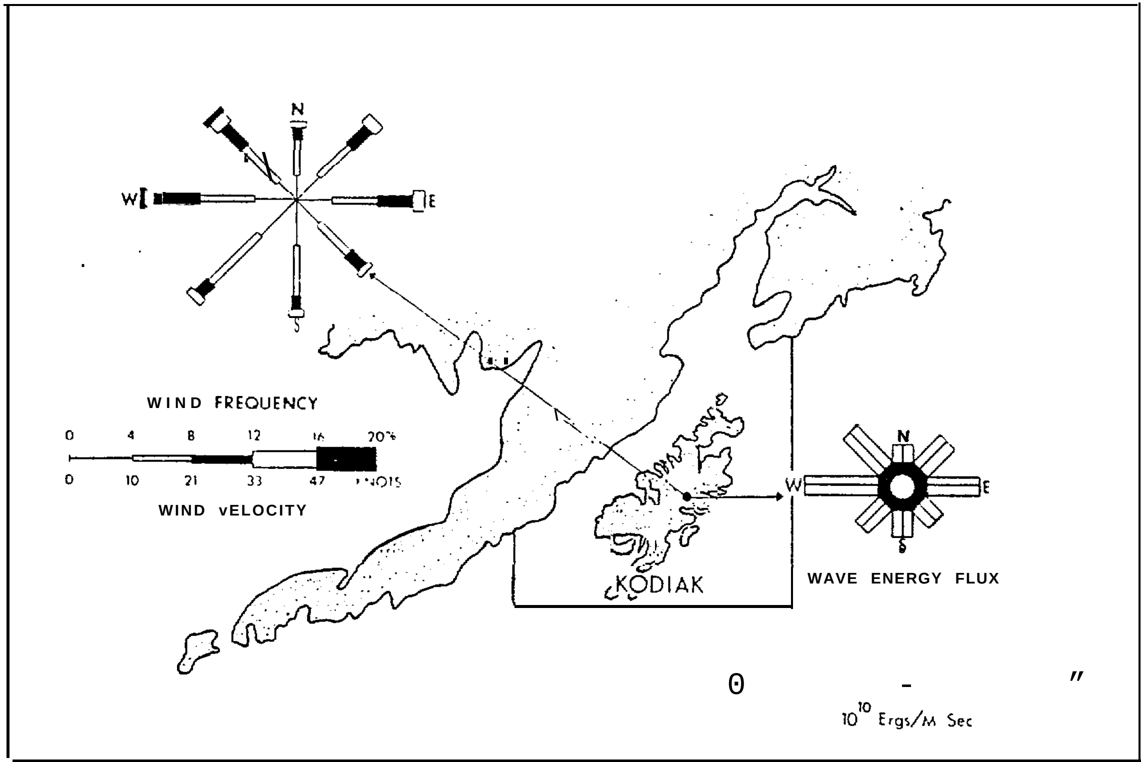

FIGURE 5. Wind and wave data taken from the Survey of Synoptic Meteorological Observations (U.S. NWSC, 1970). Note the predominance of the westerly and northwesterly winds and resultant wave energy flux.

amplitude waves are generated by cyclonic storms which are drawn into the Gulf of Alaska along low pressure troughs and funneled through the strait. Data on movement of low pressure centers are also summarized in Appendix 1.

Complex and variable nearshore bathymetry affects the local wave climate. In the vicinity of fjord mouths, nearshore water depths can be extreme, commonly greater than 100 m (300 ft) within one kilometer of the shoreline. The fjords themselves are long and narrow, and trend more or less perpendicular to the coast, resulting in severely limited fetch and abrupt changes in the trend of the coastline.

Local winds are sometimes generated at the heads of fjords by catabatic circulation and blow down along steep side slopes. This explains the development of small spits that are sometimes present in a fjord interior. The limited fetch in Shelikof Strait (60 km (45 mi) wide) also restricts wave height and period in that area.

Mean tidal range varies from 3-6 meters (m) (10-18 ft) along the coastline of the study area (AEIDC, NCC, 1977a; 1977b). Tides throughout the region are semidiurnal. The tidal range on the Alaska Peninsula is higher than that of Kodiak and Afognak Islands. Tide data are graphically summarized in Appendix I.

METHODS OF STUDY

To undertake a project covering an area as large as the Shelikof Strait region of Alaska, a technique is required that can be used to assess large sections of shoreline rapidly, and synthesize the findings onto maps of a suitable scale (1:63,360 in this study) . The method employed in this study is called the integrated zonal method, developed by Hayes and others (1973) to classify large sections of Alaskan coast for the Office of Naval Research. The addition of biological components to these geologically oriented, field studies provides an integrated approach to determine priorities for environmental protection.

By combining the field survey "data with information taken from the literature search (socioeconomic, biological, and geological baseline data), two sets of maps were prepared as a final product:

1) A file copy using a standard 1:63,360 topographic map on which color-coded biological information and numerically coded environmental classifications were presented.
2) An 8½ x 11", photo-reduced, black-and-white topographic map with a numerically coded ESI. This black-and-white series was prepared for publication purposes.

The methods used to collect the information presented on these maps are described below.

A combination of literature review and ground and aerial surveys was used to prepare the final product. During all stages of the project, the literature was reviewed for regional and local information pertaining to ecological setting, geology, climate, and socioeconomic. Upon completion of the initial literature survey, an intensive field survey was undertaken by a five-man research team between 19 May and 10 June 1980. During this period, aerial reconnaissance of the entire coastal zone was conducted. Observations and initial shoreline classifications were recorded onto USGS topographic maps using a numerical code. Aerial photographs were taken with a 35-mm camera, and descriptions were recorded on tape. During the aerial reconnaissance, the locations of ground stations were selected.

Ground study sites were then selected on the basis of all information available, using an approximate spacing of 15 km. The locations of these ground stations, 63 in total, are shown in Figure 6. Special attention was given to areas of ecological sensitivity and/or socioeconomic importance. Two types of ground stations were established: (a) rapid-survey sites, and (b) detailed profile sites.

At the rapid-survey sites, assessment of the biological and geomorphic characteristics of the ground station was conducted. A series of photographs were taken at various positions to document the biota and beach morphology present at the study site. In some cases, specimens and sediment

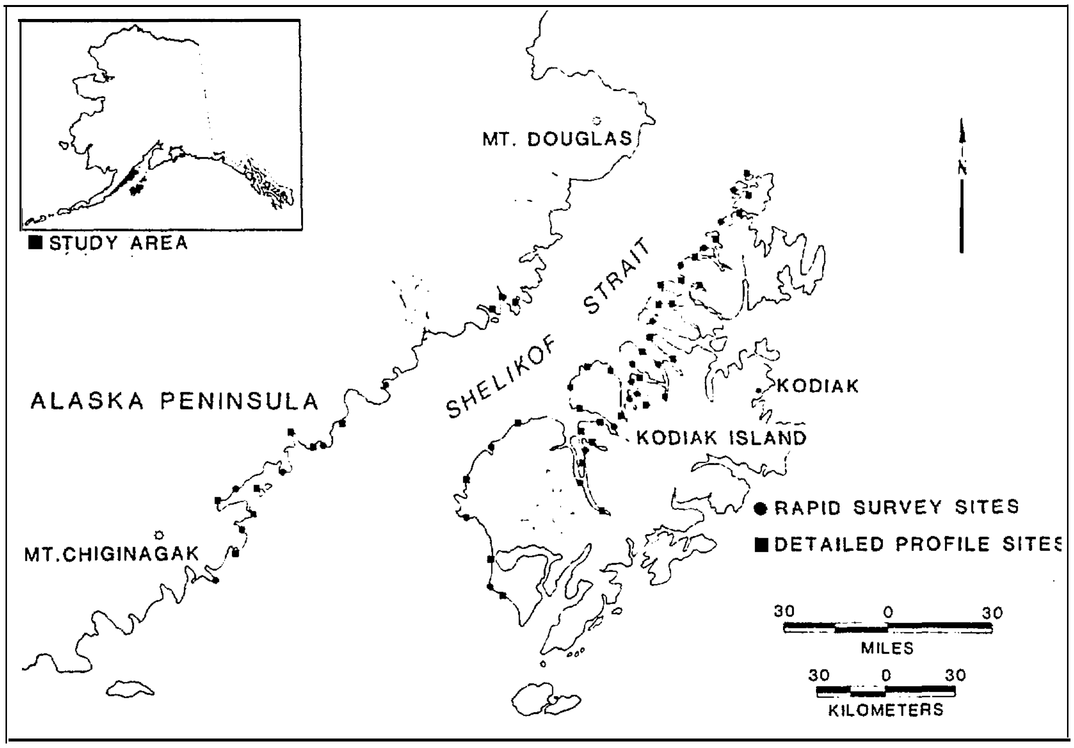

FIGURE 6. Map showing the location of the 63 ground survey stations established in the study area.

samples were collected and logged. Finally, a detailed description of the ground site was recorded on tape.

At the detailed profile sites, the following methods were used to collect pertinent data:

a) A topographic profile of the beach was surveyed using the Emery (1961) method. Descriptions of geomorphic features, sediment types, and biological information (e.g., species, densities, and abundance) were recorded along the profile.

b) Sediment samples were collected at selected locations along the profile. These samples were later analyzed for grain-size characteristics. The location of each sample was recorded on the profile data sheet. Because of an extensive sediment data base provided by an earlier study (Ruby et al., 1979), sediment samples were not collected at all ground stations during this study.

c) Intervals (area between two discrete elevation points within the profile) were set between community boundaries (ecotones) to avoid the inclusion of an edge effect within the interval. Macroflora and macroepifauna were censused within three randomly selected 1/50 m^2 quadrats within each interval. The abundance of macroflora was recorded as percent coverage of the surface area, whereas macroepifauna were recorded as numbers of individuals of each taxa per 1/50 m^2. These data are presented in discussions of oil-sensitive environments.

d) Macroinfauna were censused with triplicate cores (core diameter = 13 cm) driven 15-20 cm into the substrate within randomly selected 1/50 m^2 quadrats. Samples were passed through a l-mm mesh sieve and sorted to the lowest taxonomic group. Samples for lab analyses were preserved in ten percent formalin and then bagged and labeled. These findings were used to describe biological utilization at oil-sensitive coastal environments.

e) A sketch was made to illustrate all aspects of the profile site. Sample locations as well as biological and geomorphic features were located on the sketch.

f) Photographs were taken at several angles to document the morphological and biological aspects of each station.

g) Detailed verbal descriptions of the biological and geomorphic characteristics of the site **were** recorded on tape. Edited transcripts of these descriptions are presented in Appendix II.

These data were compiled and used to characterize and describe each environment with respect to its sensitivity to damage by spilled oil. Each environment type is represented on the maps by a number identifying its rank in the ESI; the higher the number, the greater the sensitivity of that environment to spilled oil.

In addition to characterizing the shoreline classifications, areas of special biological importance were identified. The localities of oil-sensitive, protected, or commercial species and communities are noted by colored circles. The information provided on each circle is illustrated in Figure 7. On the larger file-copy maps, the color of the circle allows rapid identification of the type of organism present: yellow = marine mammals; green = birds;

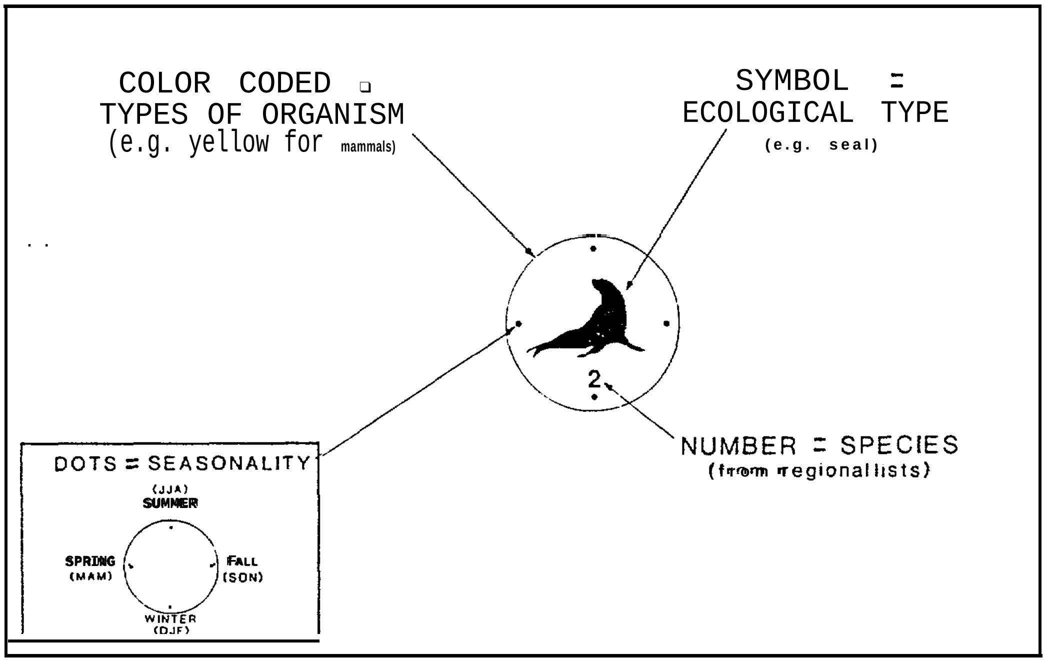

FIGURE 7. A key to the information appearing on wildlife markers, which includes type of organism, ecological type, species, and seasonal utilization.

blue = fishes; orange = shellfish. The silhouette in the center of the marker refers to the ecological groups listed in Table 1. On the black-and-white map series, organism type may be determined by matching the ecological group symbol with its corresponding symbol in Table 1. The number refers to a species or species group as listed in Appendix III. Seasonality data indicated on the outer perimeter of the color-coded marker (see Fig. 7) are shown to indicate the seasons of the year that a particular species or group of species (i.e., mixed bird colonies) are present and susceptible to oil impact. Consideration is given to such factors as reproduction, migration, and feeding behavior (Getter et al., 1981).

TABLE 1. Symbols of critical ecological groups used on the ESI maps.

RESIDENT MARINE MAMMALS		
	Seals	- Pupping or haulout grounds
	Sea Otters	- Feeding, pupping, or haulout grounds
MARINE BIRDS		
	Gulls and Terns	- Rookeries and critical forage areas
*	Diving Birds	- Rookeries and critical forage areas
FISH		
	Salmon	- Spawning areas or runs (hatched lines indicate fish runs)
SHELLFISH		
	Clams or mussels	- Abundant clam or mussel areas

As described earlier, an extensive literature search was conducted to provide this baseline information. Primary data sources utilized included the principal investigators' reports for the Alaska OCSEAP (1976-1979), Alaska Department of Fish and Game resource maps (ADFG, 1976a, 1976b; 1977a, 1977b), Sowls and others (1978), and Gusey (1979).

Socioeconomic resource information was presented to provide specialized data relative to OCS Lease Sale No. 60 and to augment the decision-making processes in the case of an oil spill. The socioeconomic information appearing on the base maps does not affect the ES I numerical rating and is designed to be used in the same manner as the biological resource information - to highlight especially sensitive areas. Socioeconomic information which was not of direct importance for consideration during the spill is excluded from these maps.

The information was gathered from four data sources:

1) The 1977 Alaska Coastal Land Status and Land Use Atlas.
2) The Bureau of Land Management - Alaska (land status records current through 1980).
3) The Draft Environmental Impact Statement prepared by BLM (Alaska Outer Continental Shelf Office) for Oil and Gas Lease Sale No. 60.
4) The map file housed as public record by the Alaska Resource Library.

Information concerning physical boundaries appearing on the maps is as exact as possible with a scale of 1:63,360. This information was limited to land having approved status. Thus, many of the lands under application by the state, native villages, or corporations of the federal government, which are potentially set aside under D-2, do not appear on these maps.

ENVIRONMENTAL SENSITIVITY INDEX (ESI)

The ESI for oil spills is based on field investigations of four massive oil spills (METULA, URQUIOLA, AMOCO CADIZ, and IXTOC I) and several smaller incidents (including spills under both tropical and ice conditions), plus an extensive literature survey. A list of the studies of major oil spills that have provided the most information on this subject is presented in Table 2.

The first application of the concept of a sensitivity index by our group was made during the mapping of the geological sensitivity of the coastline of lower Cook Inlet, Alaska, in 1976 (Hayes et al., 1976; Michel et al., 1978). That study defined an Oil Spill Susceptibility Index, which was based primarily on "the physical longevity of oil in each environment in the absence of cleanup efforts" (Michel et al., 1978, p. 109). This same principle was used by Nummedal and Ruby (1979) to map the Alaska coast of the Beaufort Sea. Gundlach and Hayes (1978b) expanded the concept to include some biological considerations. This expanded index, called the Oil Spill Vulnerability Index, was used to map several additional areas in Alaska (e.g., Ruby and Hayes, 1978).

The ESI used in this report integrates geomorphic and biological factors. Getter and others (1981) added living resource information to the index while retaining its relative simplicity. This was accomplished by indicating areas critical to fish, reptiles, birds, and marine mammals for

TABLE 2. The ESI predicts the sensitivity of coastal environments and wildlife to spilled oil. These predictions are based upon observations made during studies at the following key oil spills.

OIL SPILLS	DATE	TYPE AND AMOUNT	STUDIES
WW II Tankers U.S. East Coast	Jan.-June 1942	Various; 533,740 tons	Campbell et al. (1977)
TORREY CANYON Stilly Isles, U.K.	Mar. 1967	Arabian Gulf crude; 117,000 tons total: 18,000 tons onshore	Smith (1968)
Santa Barbara Blowout	Jan. 1969	California crude; 11,290 to 112,900 tons total; 4,509 tons onshore	Foster et al. (1971)
METULA, Strait of Magellan, Chile	Aug. 1974	Saudi Arabian crude; 53,000 tons total; 40,000 tons onshore	Harm (1974); Blount (1978)
GARVIS Florida Keys	Aug. 1975	Crude; ’210 tons	Chan (1977)
URQUIOLA, La Coruna, Spain	May 1978	Arabian Gulf crude; 110,000 tons total; 25,000-30,000 tons onshore	Gundlach and Hayes (1977); Gundlach et al. (1978)
AMOCO CADIZ Brittany, France	Mar. 1978	Arabian Gulf crude; 223,000 tons total	Gundlach and Hayes (1978b); Hayes et al. (1979)
HOWARD STAR Tampa Bay	Oct. 1978	Crude and distil-late; ’140 tons	Getter et al. (1980b)
PECK SLIP Eastern Puerto Rico	Dec. 1978	Number 6 oil; 1,500 tons	Getter et al. (1980a); Gundlach et al. (1979)
IXTOC I Gulf of Mexico	June 1979 to April 1980	Crude oil; several hundred thousand tons	Getter et al. (1980c); Gundlach et al. (1981)
BURMAH AGATE Texas	Nov. 1979	Crude and refined product	Thebeau and Kana (1981)

feeding and reproduction with color-coded wildlife symbols. These symbols include the seasons in which these species use certain areas. Access points to the shore and facilities such as marinas and boat ramps are also indicated on the maps. These refinements were applied to ESI maps used in energy port planning projects (Hayes et al., 1980) .

ESI maps were first tested during a major oil spill following the IXTOC I blowout in the Gulf of Mexico. The ESI maps became an integral part of the overall federal response plan to protect the Texas coast, providing the scientific basis for setting protection priorities and cleanup strategies. Since then, ESI mapping has been carried out in Massachusetts, South Carolina, the remainder of Texas, southern California, Puget Sound (Washington), and Shelikof Strait, Pribilof Islands, and Norton Sound (Alaska).

In addition to combining geomorphic and biological aspects into the index, socioeconomic information was superimposed graphically on the ESI maps. National and state park boundaries, mining lease sites, and native subsistence areas are among the parameters highlighted. Detailed descriptions of biologic and socioeconomic information are presented later in this text.

The shoreline classifications defined for the Shelikof Strait area of Alaska are presented in Table 3 in order of increased potential for damage by oil spills.

TABLE 3. Distribution of shoreline types in Shelikof Strait.

COASTAL TYPE	KILOMETERS	MILES	% TOTAL SHORELINE	ESI CLASSIFICATION
Exposed rocky headlands	243.3	150.8	10.0	1
Wave-cut platforms	402.3	249.4	16.4	2
Fine/medium-grained sand beaches	1.0	0.6	0.04	3
Coarse-grained sand beaches	42.0	26.0	1.7	4
Exposed tidal flats (low biomass)	16.5	10.2	0.7	5
Mixed sand and gravel beaches	911.0	564.8	37.0	6
Gravel beaches	223.5	138.6	9.0	7
Exposed tidal flats (moderate biomass)	4.3	2.7	0.17	7a
Sheltered rocky shores	222.3	137.8	9.1	8
Sheltered tidal flats	239.0	148.2	9.7	9
Marshes	153.7	95.3	6.2	10
	2,458.9	1,524.4		

ENVIRONMENTAL SENSITIVITY INDEX
FOR THE SHELIKOF STRAIT REGION OF ALASKA

SHORELINE TYPES

1) Exposed rocky headlands
2) Wave-cut platforms
3) Fine/medium-grained sand beaches
4) Coarse-grained sand beaches
5) Exposed tidal flats (low biomass)
6) Mixed sand and gravel beaches
7) Gravel beaches
7a) Exposed tidal flats (moderate biomass)
8) Sheltered rocky shores
9) Sheltered tidal flats
10) Marshes

BIOLOGICAL RESOURCE INFORMATION

Mammals

Birds

Fish; Anadromous Fish Runs

Shellfish

BROWN BEAR FEEDING AREA
SITKA BLACK TAIL DEER FEEDING AREA

SOCIOECONOMIC INFORMATION

Mining Lease Sites

Forest Preserves

Archaeological Sites

Private Properties

Landing Strips

Tidal Lease Sites

Each environmental classification is discussed in the following section.

1) EXPOSED ROCKY HEADLANDS

Description

- Physical
  - Steep scarps in bedrock
  - Boulders may be found at base of scarp
  - Exposed to strong waves and currents
- Plants
  - Dominant plants are attached algae
  - Zonation is controlled by slope of rock face and exposure to waves
  - On steep shores, an upper zone of rockweed and a lower zone of kelp are present
  - On less steep shores, a third zone of brown, green, and red algae (such as Gigartina, Rhodemela, Halasaccion, Porphyra, Syctosiphon, and Ulva) is present
  - Surface plant coverage is high; (mean coverage = 86.4%)
- Animals

  Barnacles and mussels are dominant_animals and form two zones

  Barnacles have maximum densities ($X = 19,110/m^2$) in the upper intertidal to supratidal zones

  Mussels have maximum densities ($\bar{X} = 4,140/m^2$) in the mid to lower intertidal zones

  Littorine organisms were observed throughout the intertidal zone (maximum densities: $\bar{X} = 4,006/m^2$)

  Infauna are minimal due to rocky substrate

  "Underrock" fauna populations are variable, but generally sparse in upper intertidal zones and moderate to heavy in lower intertidal zones

Predicted Oil Behavior

- Along very steep shores:
  - most oil would be held offshore by reflected waves
  - deposited oil would be removed rapidly by waves
- On less steep shores:
  - upper intertidal and supralittoral zones would be most heavily oiled
  - six to nine months would be required for natural removal
  - oil trapped in tidal pools probably would kill residing organisms

Potential Biological Damages

- Greatest exposure would be to upper intertidal, supralittoral, and tide pool organisms
- Impact to fauna and flora would be low due to short-term oil persistence
- Mortalities may be caused by smothering in cases of heavy oiling
- Removal of grazers may cause temporary increased productivity of attached algae
- Seals using exposed rocky headlands as haulout areas may be affected by oil on the body; attempts to remove oil by licking results in ingestion
- Many bird species (alcids, gulls, terns) nest on offshore, exposed rocky islands and spend much time in the nearshore waters; birds would be oiled during attempts to land in waters becalmed by oil

Recommended Cleanup Activity

- On very steep shores, no cleanup would be necessary
- On less steep shores, high-pressure spraying would be effective only while oil remains liquid

SK F-I
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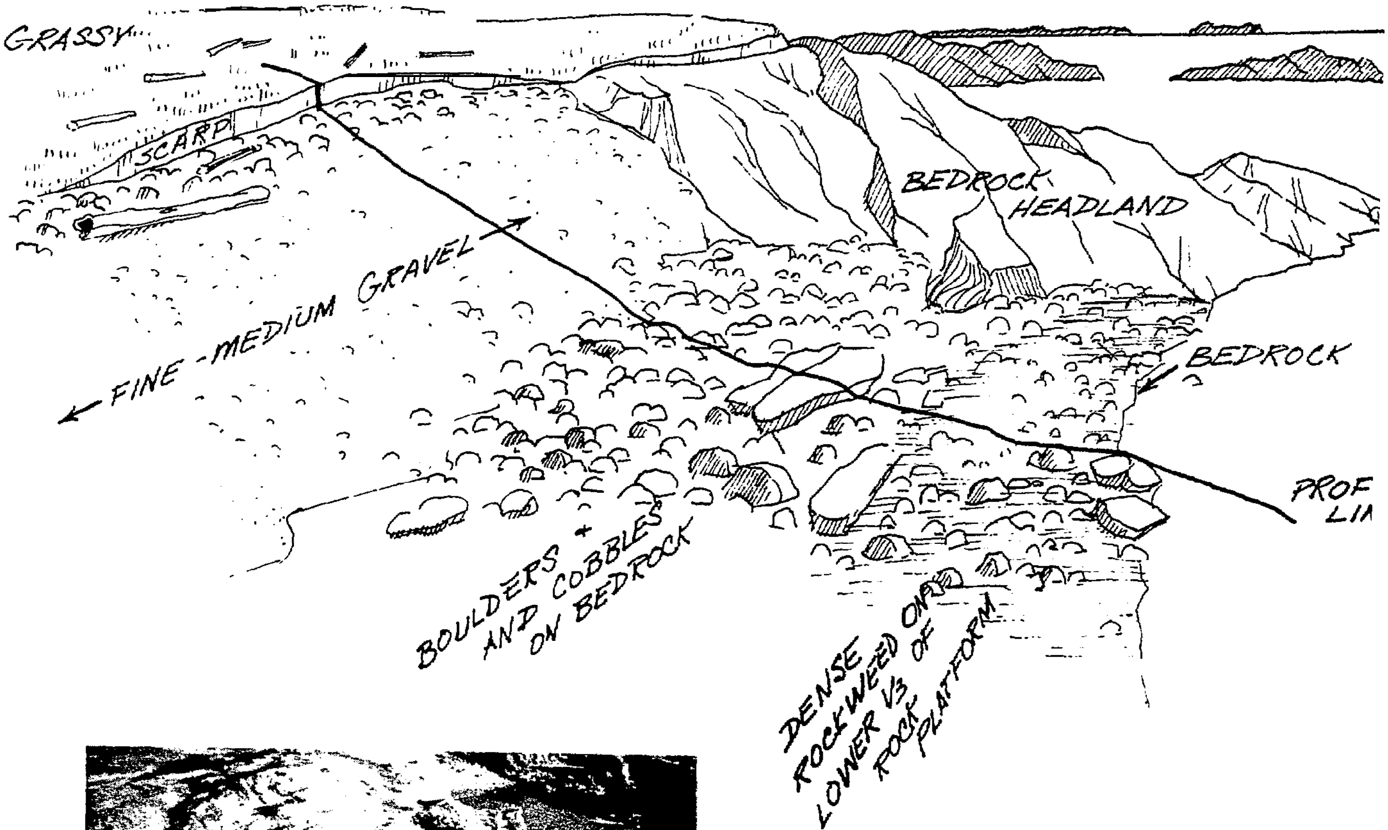


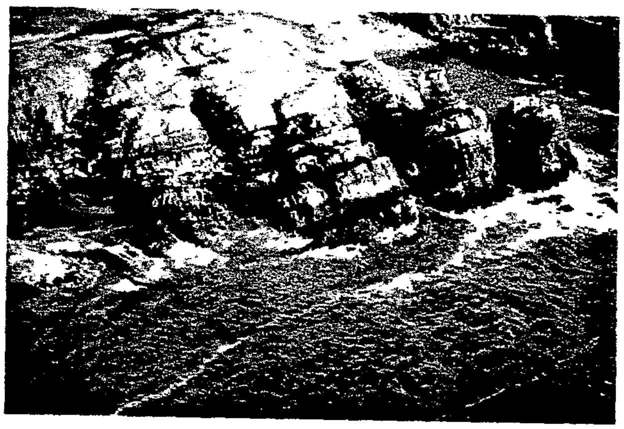


FIGURE 8. Aerial view of an exp rocky headland in the Kodiak Archi ago. The upward tilting strata al for the development of small tidal pools . Reflecting waves and high-wave energies would minimize heavy oiling and oil persistence.

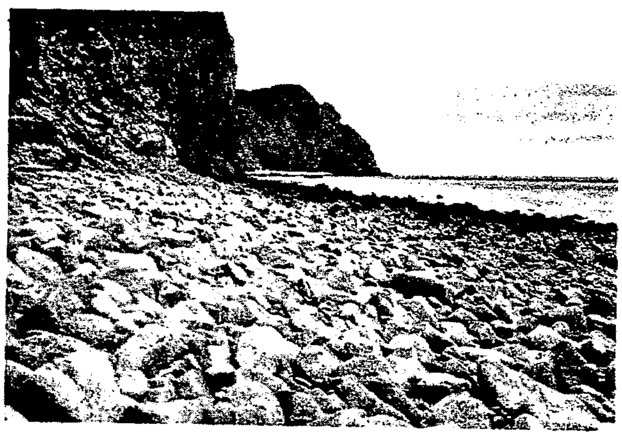


FIGURE 9. Large boulder and col beaches are commonly associated w: exposed rocky headlands. These beaches usually overlie a bedrock platform which is formed as the headland erodes.

FIGURE 10. Aerial view of an isolated exposed rocky headland. Note the large boulders immediately adjacent to the headland (arrow). Sediments generally become finer in the downdrift direction away from the headland.

FIGURE 11. Exposed rocky shore showing four distinct biological zones: (1) barnacle (*Balanus cariosus*) zone, (2) blue mussel zone, (3) brown and red algae zone, and (4) barnacle (*Balanus glandula*) zone.

FIGURE 12. Close-up of upper intertidal, attached algae zone on an exposed rocky shore. Common species found in this zone are rockweed (*Fucus distichus*); red algae (*Endocladia mureata*); barnacle (*Chthamalus dalli*); and periwinkle (*Littorina sitkana*).

2) WAVE-CUT PLATFORMS

Description

- Physical
  Composed of either glacial till or bedrock
  Along till-backed shorelines:
  - composed of eroding till having a steep, exposed scarp
  - usually narrow platform and beach
  - beach composed of mixed sand and gravel/cobbles
  - exposed to high waves
  - beach sediments are highly mobile

  Along bedrock shorelines:
  - boulder-strewn
  - contain narrow to very wide platforms
  - exposed to high waves
  - backed by steep, rock scarps
- Plants
  - Dominant plants are attached algae on bedrock platform
  - Dominant species throughout the intertidal zone are rockweed
  - Red moss algae occurs in the upper and middle intertidal zones
  - Kelp grows in lower intertidal zone
  - Maximum surface coverage is high ($\bar{X}$ = 93.4%)
- Animals
  - Density is moderate to heavy, but generally lower than exposed rocky headlands
  - Two dominant zones occur: (1) barnacles and littorine snails and (2) mussels; both zones have rich epifaunal communities
  - Diverse "underrock" communities of sea urchins, starfish, polychaetes and amphipods are present

Predicted Oil Behavior

- Short-term persistence of oil would occur along upper intertidal sediments (mixed sand and gravel)
- Some biological damage would occur, primarily to lower intertidal community

Potential Biological Damages

- Oil remaining in the upper intertidal and supralittoral zones would smother barnacles and snails, and would retard recolonization in proportion to its persistence
- Oil seeping into cracks and crevices between rocks would impact the "underrock" organisms
- Though rockweed has a high resistance to oil because of its mucilaginous covering, associated epifauna (amphipods, polychaetes, chitons) would be contaminated by the oil, causing die-off by mechanical (smothering) or physiological (ingestion or absorption) means

Recommended Cleanup Activity

- High-pressure spraying of rocks may be effective
- Manual/mechanical cleanup of thick oil accumulations is recommended with caution

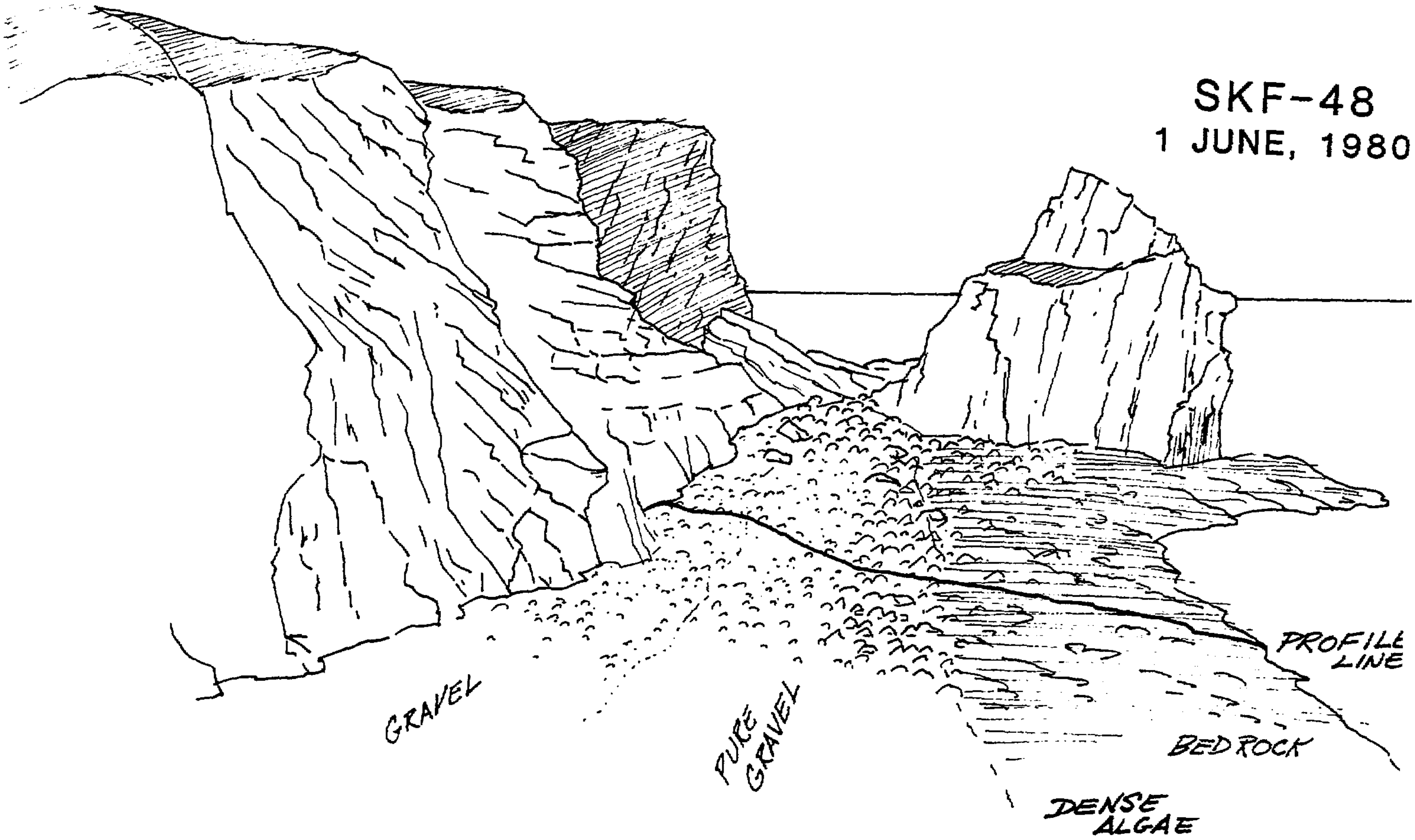


FIGURE 13. Aerial view of a wave-cut platform on the Alaska Peninsula. These environments are subject to high wave energy and persistence of oil would be low. Small tidal pools (arrow) are formed as less resistant strata are eroded from the platform surface.

FIGURE 14. Aerial view of eroding till scarp. Platforms are also formed as glacial till sediments are eroded. The resulting platform is generally narrow and overlain by large boulders and cobbles. Because of high wave energy, persistence of oil would be short.

FIGURE 15. Lower intertidal zone of wave-cut platform. Rocks are covered by lamanarian and alarian kelps.

FIGURE 16. Close-up view of lower intertidal zone of wave-cut platform. Alarian kelps, red algae, blue mus-els, and barnacles are present. Heavy oiling could asphyxiate mus-sels and barnacles. Kelps have a mucilaginous coating that helps protect them from the effects of oil.

FIGURE 17. Tide pools are common . in bedrock platforms and contain many organisms. Organisms seen in this photo include sea anemones, blue mussels, barnacles, littorine snails and pink corraline algae.

3) FINE/MEDIUM-GRAINED SAND BEACHES

Description

- Physical
  - Usually gentle slope with broad, flat profile
  - Often exposed to moderate and high wave energy
  - Boulder or gravel accumulations may be present in the lower intertidal zone
- Plants
  - Scattered beach grasses and plants growing at the base of the escarpments; no vegetation growing on storm beach or intertidal zones
  - Beach wrack composed of decaying kelps and rockweed
- Animals
  - Insects and amphipods associated with beach wrack are present
  - Burrowing amphipods and polychaete worms present in the upper and mid intertidal zones
  - Some burrowing clams present in the lower intertidal to subtidal zones
  - Density and diversity are low

Predicted Oil Behavior

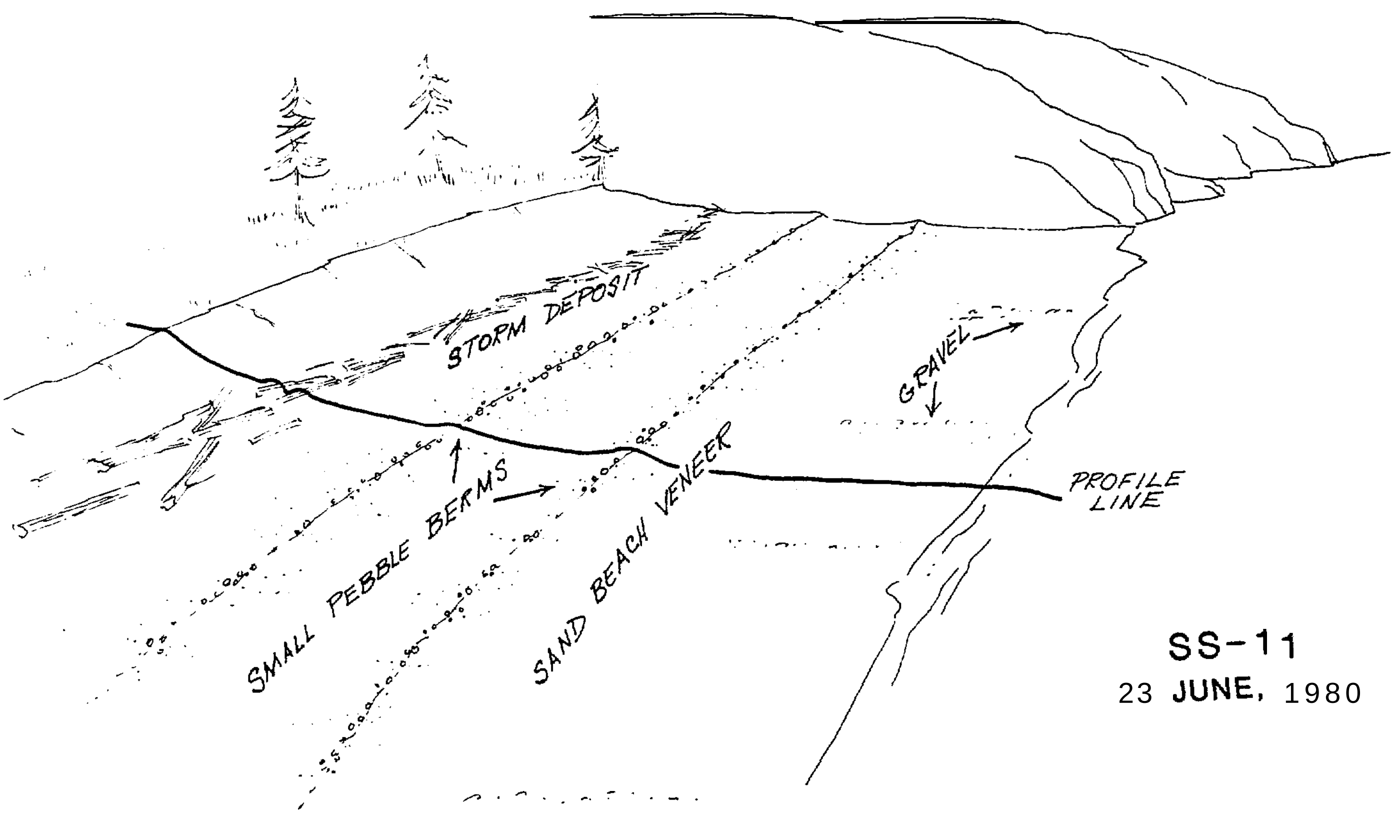
- Large accumulations would cover entire beach face
- Small accumulations would be deposited primarily along high tide swash-lines
- The compact sediments of this beach type prevent deep penetration of oil
- Oil may be buried to a maximum of 10-20 cm along the upper beach face

Potential Biological Damages

- Biological damage would be limited
- Intertidal organisms would have short-term exposure because oil would be deposited over berm crest

Recommended Cleanup Activity

- Cleanup should begin only after majority of oil is deposited onshore
- Cleanup should concentrate on removal of oil from upper swash zone
- Mechanical methods should be used cautiously but, generally, fine-grained sand beaches are among the easiest to clean mechanically because of their hard, compact substrate
- Removal of sand should be minimized



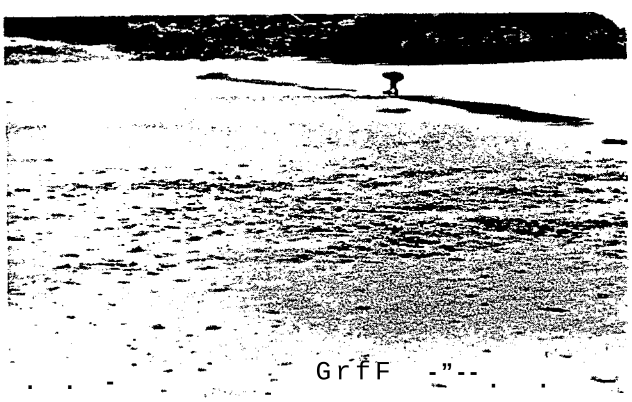


FIGURE 18. Ground view of a fine/ medium- grained sand beach at station SKF-42 . Fine-grained sand beaches are not common on Shelikof Strait and are usually found as pocket beaches between headlands. Sediments generally have a gravel or cobble fraction. Oil persistence in this environment would be low.

FIGURE 19. Ground view of station SKF-29 . Sediments at this station are strongly bimodal. The large cobbles and boulders seen here are eroded from glacial till. Species diversity and density is low and biologic damage from oil impact would be minimal.

4) COARSE-GRAINED SAND BEACHES

Description

- Physical
  - Usually displays a short, steep beach face with a wide backshore
  - Sediments loosely compacted
  - Beach morphology responds rapidly to changing wave and tidal conditions
- Plants
  - Vegetation restricted to intermittent cover near scarp
  - Beach wrack comprised primarily of decomposing kelp
- Animals
  - Low species diversity and density
  - A few polychaetes were found at or between low and middle intertidal zones
  - Beach wrack provides a habitat for amphipods and insects
  - Some burrowing amphipods observed at high intertidal zone near berm crest
  - Shorebirds were observed feeding in beach wrack associated with driftwood wrack at base of scarp

Predicted Oil Behavior

- Large accumulations would cover entire beach face
- Small accumulations would be deposited primarily along high tide swashlines
- Oil may be buried deeply along berm and berm runnel

Potential Biological Damages

- Biological damages would be minimal
- Supratidal organisms would suffer only short-term exposure unless oil penetrates substrate
- Where oil penetrates substrate, some die-offs of infauna would be expected

Recommended Cleanup Activity

- Cleanup should commence only after majority of oil is deposited onshore
- Cleanup should concentrate on removal of oil from upper swash zones
- Mechanical methods should be used cautiously
- Sediment removal should be minimized

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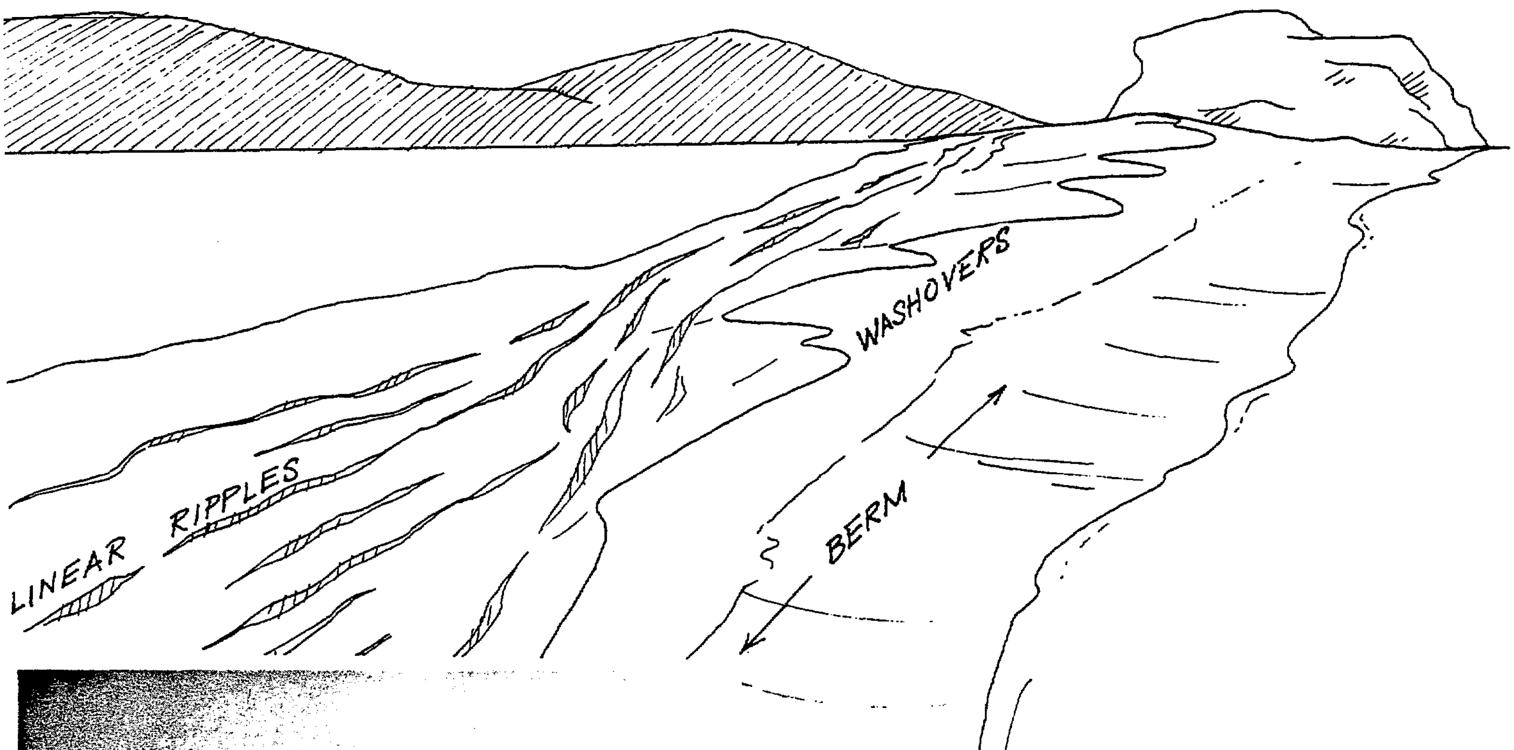
1 JUNE, 1980



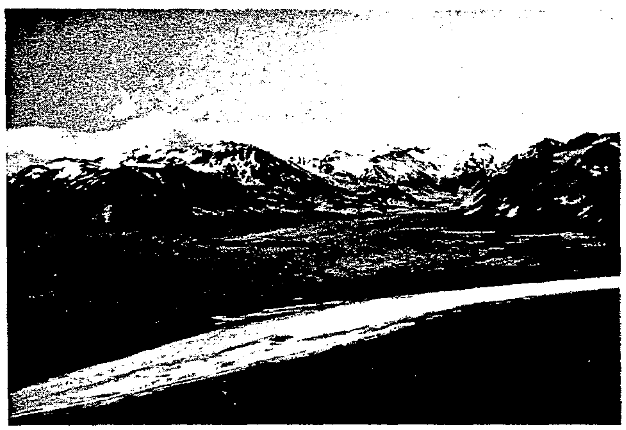


FIGURE 20. Aerial view of coarse-grained sand beach along a large spit complex. Coarse-grained sand beaches, like fine/medium-grained sand beaches, comprise a low percentage of the shoreline along Shelikof Strait.

FIGURE 21. Ground view of coarse-grained sand beach. Because sediments are loosely compacted and respond rapidly to changing wave and tidal conditions, oil would be buried and retained longer than in fine-grained sand beaches. Biological damage would be minimal.

5) EXPOSED TIDAL FLATS (LOW BIOMASS)

Description

- Physical
  - Sediments range from fine-grained sand to gravel
  - Sediments are generally very mobile due to waves and tidal currents
  - Associated with tidal deltas and, in some areas, front sand or mixed sand and gravel beaches
- Plants
  - Very little flora are present
  - Mobile substrate prevents attachment of algae
- Animals
  - When present, benthic infauna are dominant organisms
  - Species diversity and density vary with substrate
  - Clams, polychaetes, and burrowing crustaceans are the most common microorganisms
  - Faunal density is lowest at high intertidal zone, increasing at mid and low intertidal zones
  - In sandy bottom flats exposed to high wave energy, deep-burrowing clams (e.g., razor clams) dominate simple benthic communities
  - Birds utilize exposed flats as roosting and foraging areas

Predicted Oil Behavior

- Most oil would be pushed across tidal flat surface onto adjacent shores by wave and tidal activity
- Mobile sediments in coarser grained flats would prohibit accumulation

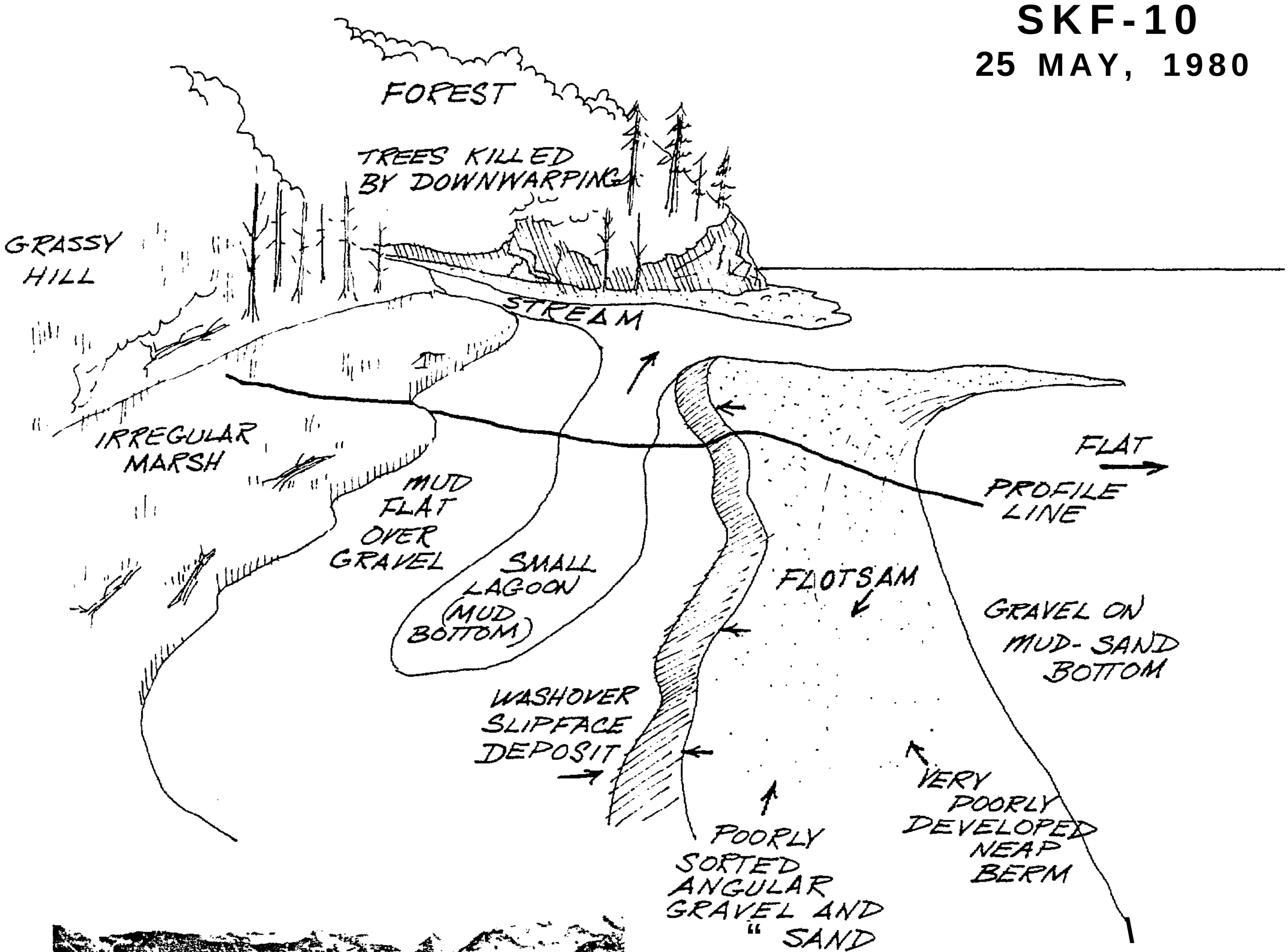
Potential Biological Damages

- Oil would impact organisms at high tide swash zone and in pools left during receding tide
- Oil left on substrate during receding tide would:
  - penetrate burrows of clams and other burrowers
  - come in contact with or be ingested by these organisms
  - be incorporated into the sediments
- Birds foraging on flats would be exposed to oil by:
  - feather oiling
  - ingestion of immobilized or weakened organisms resulting from oil contamination

Recommended Cleanup Activity

- No cleanup usually necessary in areas where oil accumulation is low
- Removal of sediment should be avoided

SKF-10
25 MAY, 1980



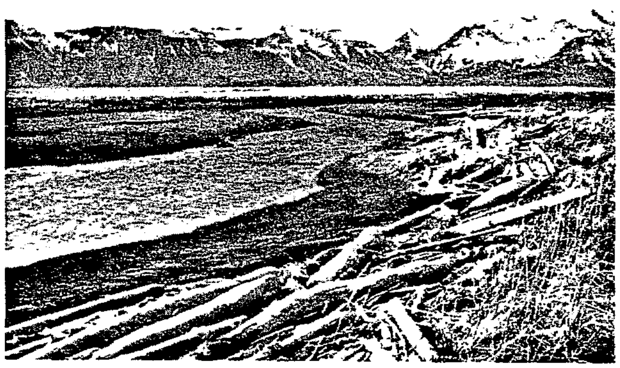


FIGURE 46. Ground view of a marsh in Wide Bay on the Alaska Peninsula. Two types of marshes are common in Shelikof Strait: (1) fringing marshes (shown here), and (2) broader, more well-developed marsh systems.

FIGURE 47. Ground view of a well-developed marsh and channel system. During a spill, the tidal creeks would act as conduits transporting the oil into the marsh system.

FIGURE 48. Aerial view of fringing marsh. The marsh develops in the areas exposed to the lowest wave energy (arrows).

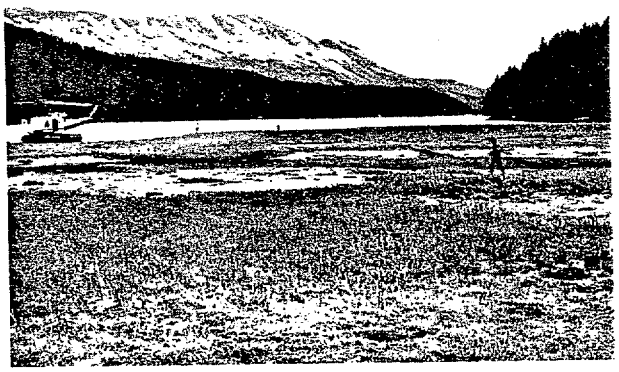


FIGURE 49. Ground view of fringing marsh. Oil deposited in these areas would be present for many years because of low-wave energy conditions. Impact on marsh grasses would be severe if oil becomes incorporated into the sediments. Heavy oiling would kill seasonal growth and if oil remains through the winter, new growth would be affected.

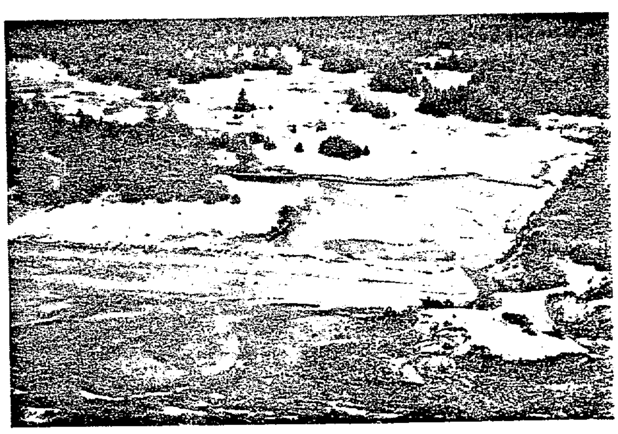


FIGURE 50. Aerial view of fringing marsh (arrow) located along a sheltered tidal flat. Most fringing marshes observed were associated with a freshwater influx. The marshes usually contained only one grass species. Few macroepifauna were present.

6) MIXED SAND AND GRAVEL BEACHES

Description

- Physical
  - Sediments may be either dominantly mobile or stable, dependent on location of beach with respect to wind and wave conditions
  - Generally composed of coarse sand and gravel
  - Natural sorting processes may form sand "stringers" at lower intertidal zone
- Plants
  - Dominantly mobile substrate:
    - Algae density is either very low or nonexistent because of scouring action from active movement of beach sediments due to waves
  - Dominantly stable substrate:
    - Attached algae density is moderate with a mean surface coverage of 63 percent
    - Dominant species is rockweed with *Syctosiphon*, *Porphyra*, and *Enteromorpha* comprising other common algae species
- Animals
  - Dominantly mobile substrate:
    - Few macrofaunal organisms are able to survive in mobile sand/gravel beaches
  - Dominantly stable substrate:
    - Two major communities observed: (1) an upper intertidal barnacle community and (2) a mussel community at the mid and lower intertidal zones
    - Amphipods observed beneath larger rocks
    - Foraging area for shorebirds, crows, and gulls

Predicted Oil Behavior

- Oil would be deposited primarily high on the beach face
- Oil would be deposited over the lower beach face only under heavy accumulations
- Burial may be deep along berm
- Long-term persistence of oil is dependent on incoming wave energy; in sheltered areas, oil would remain for several years

Potential Biological Damages

- Dominantly mobile substrate:
  - Biological damage would be minimal
- Dominantly stable substrate:
  - Biological damage would be moderate to heavy
  - Heavy oiling would smother barnacle and mussel communities
  - Infauna would be affected by oil percolating through coarse sediments
  - Birds would be affected by oiled feathers and possible ingestion of contaminated prey

Recommended Cleanup Activity

- Oil should be removed primarily from upper swashlines
- High pressure spraying may be necessary
- Mechanical reworking of sediment into the surf zone effective if oil accumulation is heavy enough to require it
- Removal of sediment should be restricted

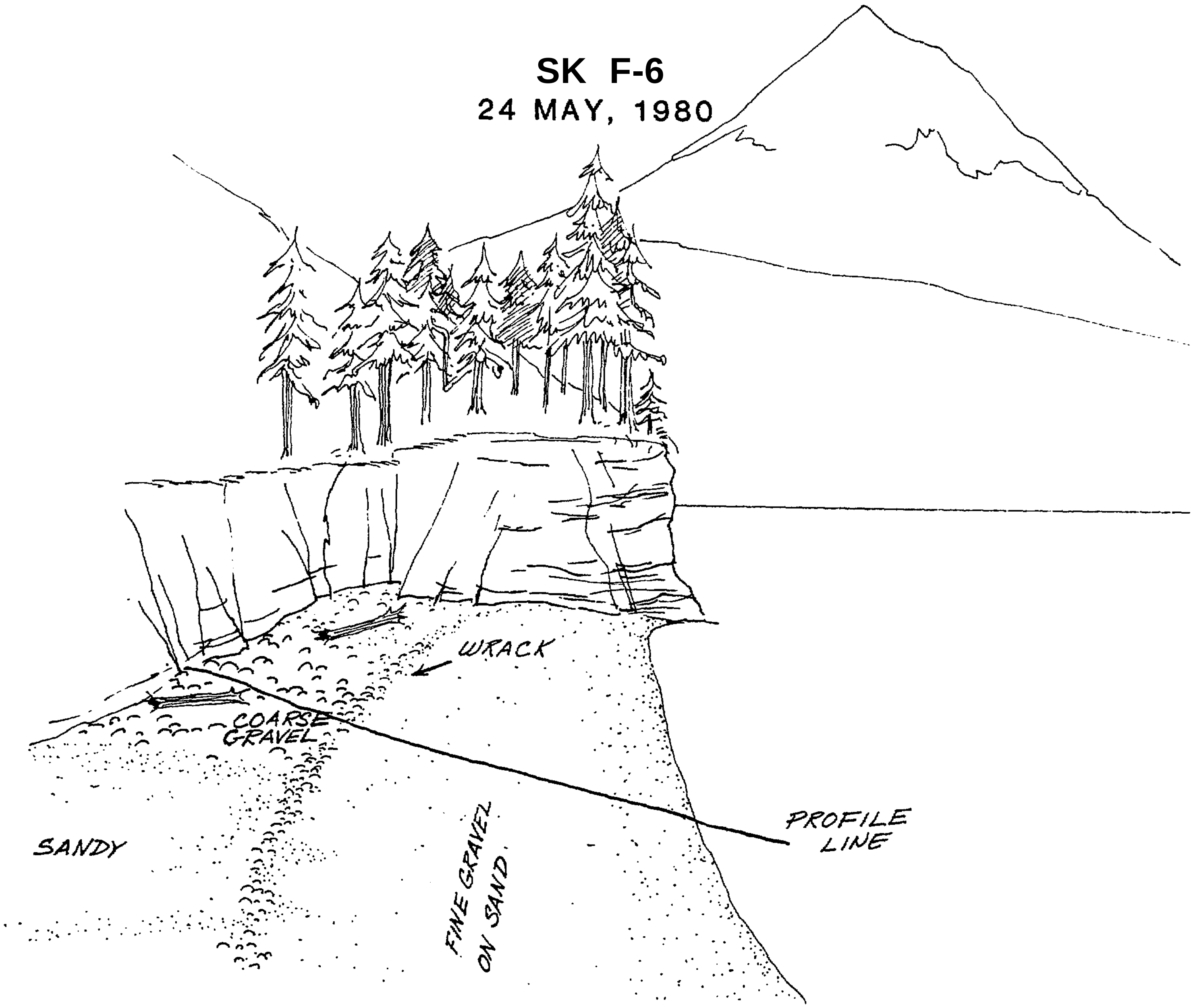


FIGURE 26. Ground view of typical mixed sand and gravel beach. Sediments can be dominantly mobile (as shown here) or dominantly stable depending on the location of the beach.

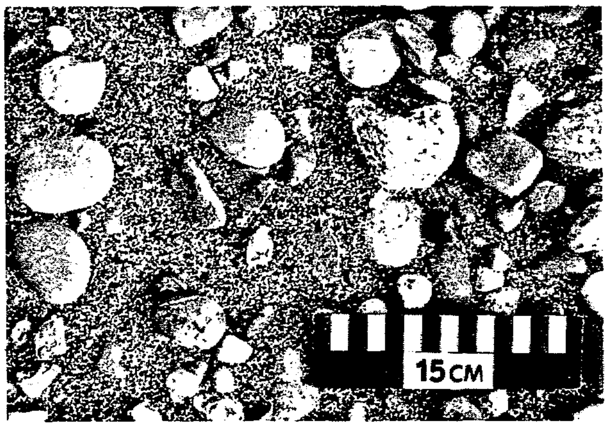


FIGURE 27. Close-up view of sediments from mixed sand and gravel beach. Note the well-rounded gravel component common on high-energy beaches with mobile substrates.

FIGURE 28. Ground view of a mixed sand and gravel beach with a dominantly stable substrate (SKF-35). The arrow indicates a dense mussel community common at relatively sheltered mixed sand and gravel beaches. Biological damage would be moderate to heavy and oil persistence would be extended over several years.

FIGURE 29. As shown in this ground view (arrow), sand "stringers" may develop near the lower intertidal zone.

7) GRAVEL BEACHES

Description

- Physical
  - Sediments may be either dominantly mobile or stable, dependent on location of beach with respect to wind and wave activity
  - Composed mostly of gravel, cobbles, and boulders (<10% sand)
  - Well-sorted gravel commonly located on upper beach face
  - Sediments range from angular to well-rounded
- Plants
  - Dominantly mobile substrate:
    - Beaches generally devoid of vegetation
    - Green filamentous algae observed on small boulders
  - Dominantly stable substrate:
    - Rockweed is dominant algae - Gigartina, Odonthalia, and Rhodemela comprising other algaes
    - Kelp grows at low intertidal waterline
    - Density is moderate to high (surface coverage $\bar{X}$ = 73.3%)
- Animals
  - Dominantly mobile substrate:
    - Beaches devoid of fauna
  - Dominantly stable substrate:
    - Faunal densities are moderate to high: mussels ($\bar{X} = 6{,}738/m^2$), barnacles ($\bar{X} = 12{,}252/m^2$), and littorine snails ($\bar{X} = 1{,}741/m^2$)
    - Two distinct faunal communities occur: (1) barnacle community at supralittoral to upper intertidal zones, and (2) mussel community at mid to lower intertidal zones
    - Other common species: littorina (moderate to high densities), hermit crabs, and limpets

Predicted Oil Behavior

- Oil would be deposited primarily on the upper beach face
- Oil would percolate easily into the sediments
- Burial may be exceptionally deep along berm

Potential Biological Damages

- Dominantly mobile substrate:
  - Damages would be minimal
- Dominantly stable substrate:
  - Barnacle community would be most highly impacted due to long-term persistence of oil
  - Mid and lower intertidal zones would have short-term, moderate impact because of natural cleaning processes
  - Oil would percolate between rocks, and "underrock" organisms would be impacted

Recommended Cleanup Activity

- High pressure spraying may be required
- Mechanical reworking of sediment into the surf zone may be effective if oil accumulation is enough to require it
- Removal of sediment should be restricted

sKF-46
31 MAY, 1980

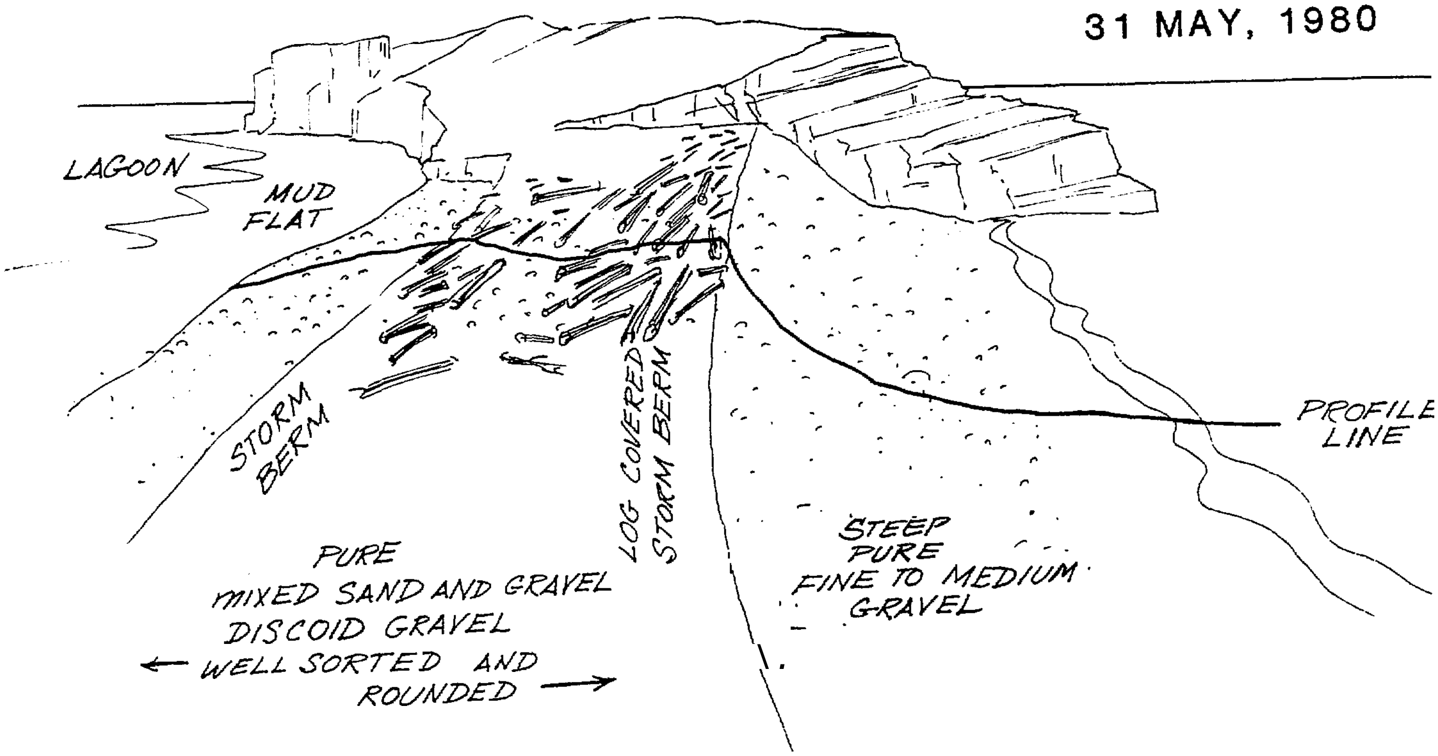


FIGURE 30. Ground view of SKF-46 showing a virtually pure gravel beach. Oil would percolate deeply into sediments making cleanup extremely difficult .

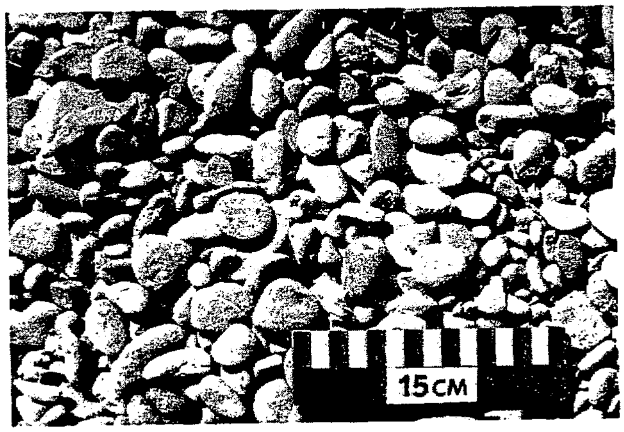


FIGURE 31. Close-up of pure gravel sediments. These high-energy environments respond rapidly to changing wave and tidal conditions. Burial of oil would be especially deep along developing berms.

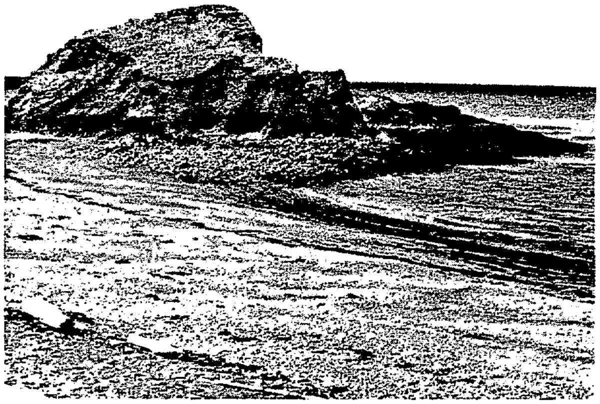


FIGURE 32. Ground view showing relationship of gravel beaches with other environments. In this photo, the gravel beach is positioned below an exposed rocky headland, and immediately adjacent to a mixed sand and gravel beach.

FIGURE 33. In some areas of Shelikof Strait, large boulders and cobbles are the dominant components on gravel beaches. Oil would easily percolate through these sediments. The dark area (arrow) is attached filamentous green algae which commonly occurs at the upper intertidal zone where wave energy is low.

FIGURE 34. Close-up of algae covered boulders. Note dense aggregation of periwinkles (*Littorina sitkana*).

7a) EXPOSED TIDAL FLATS (MODERATE BIOMASS)

Description

- Physical
  - Sediments range from mud to gravel
  - Sediments generally are less mobile than those described in ESI=5
  - Associated with tidal deltas and prograding spits
- Plants
  - Very little flora are present
- Animals
  - Benthic infauna are dominant organisms
  - Species diversity and density vary with substrate, which ranges from mud to mixed sand and gravel
  - As in ESI=5, clams, polychaetes, and burrowing crustaceans are most common microorganisms, but are found in greater abundance
  - Faunal density is lowest at high intertidal zone, increasing at mid and lower intertidal zones
  - In high wave energy areas, exposed sand bottom flats are found
  - Deep burrowing clams such as razor clams dominate simple benthic communities
  - Birds utilize exposed flats as roosting and foraging areas

Predicted Oil Behavior

- Most oil would be pushed across tidal flat surface onto adjacent shores by wave and tidal activity
- Mobile sediments in coarser-grained flats would prohibit accumulation

Potential Biological Damages

- Oil would impact organisms at high tide swash zone and in pools left during receding tide
- Oil laid down on substrate by receding tide would:
  - Penetrate burrows of clams and other burrowers
  - Come in contact with or be ingested by these organisms
  - Be incorporated into the sediments
- Birds foraging on flats during low tide would be exposed to oil by:
  - Feather oiling
  - Ingestion of oil from preening of contaminated feathers
  - Ingestion of organisms which have been immobilized or weakened by oil contamination

Recommended Cleanup Activity

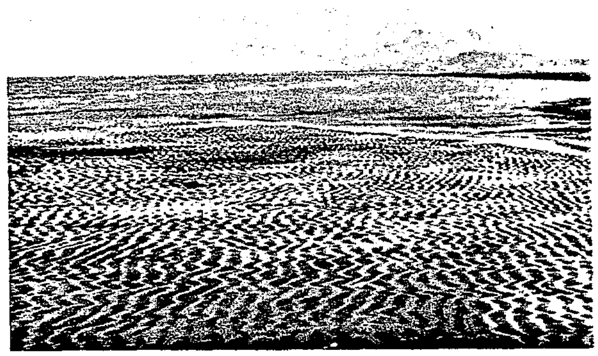
- No cleanup usually necessary in areas where oil accumulation is low
- Removal of sediment should be avoided
- Use of heavy machinery would tend to mix oil into sediments

P-8

22 JUNE 1980

FIGURE 35. Aerial view of an exposed tidal flat associated with a delta complex. Exposed to moderate (vs high) wave and tidal currents, tidal flats such as the one pictured here host larger populations than those of ESI=5.

FIGURE 36. Ground view of exposed tidal flat. Oil would be pushed across flat surface by wave and tidal activity to accumulate in the upper swash-lines.



8) SHELTERED ROCKY SHORES

Description

- Physical
  - Composed of bedrock and boulders
  - Dependent on seasonal storm activity, typically a low energy environment
  - May have steep erosional scarp fronted by boulders and/or mixed sand and gravel beaches
- Plants
  - In sheltered rocky shores, rockweed grows throughout the intertidal zone and is the most common algae
  - Surface coverage is highly variable but usually heavy (r = 23-100%; X = 63.3%)
  - Other common algae are *Halasaccion, Odonthalia, Rhodomela*, and *Porphyra*
- Animals
  - Barnacles occur throughout the intertidal zone in moderate to high densities
  - Heaviest littorine densities are found at the supralittoral and upper intertidal zones
  - Sea urchins, polychaetes, starfish, and amphipods are found under rocks
  - Limpets and chitons are attached to rocks at the mid and lower intertidal zones

Predicted Oil Behavior

- Long-term (1-1½ years) persistence of oil, especially between rocks and boulders
- Oil would penetrate more deeply into well-sorted gravels

Potential Biological Damages

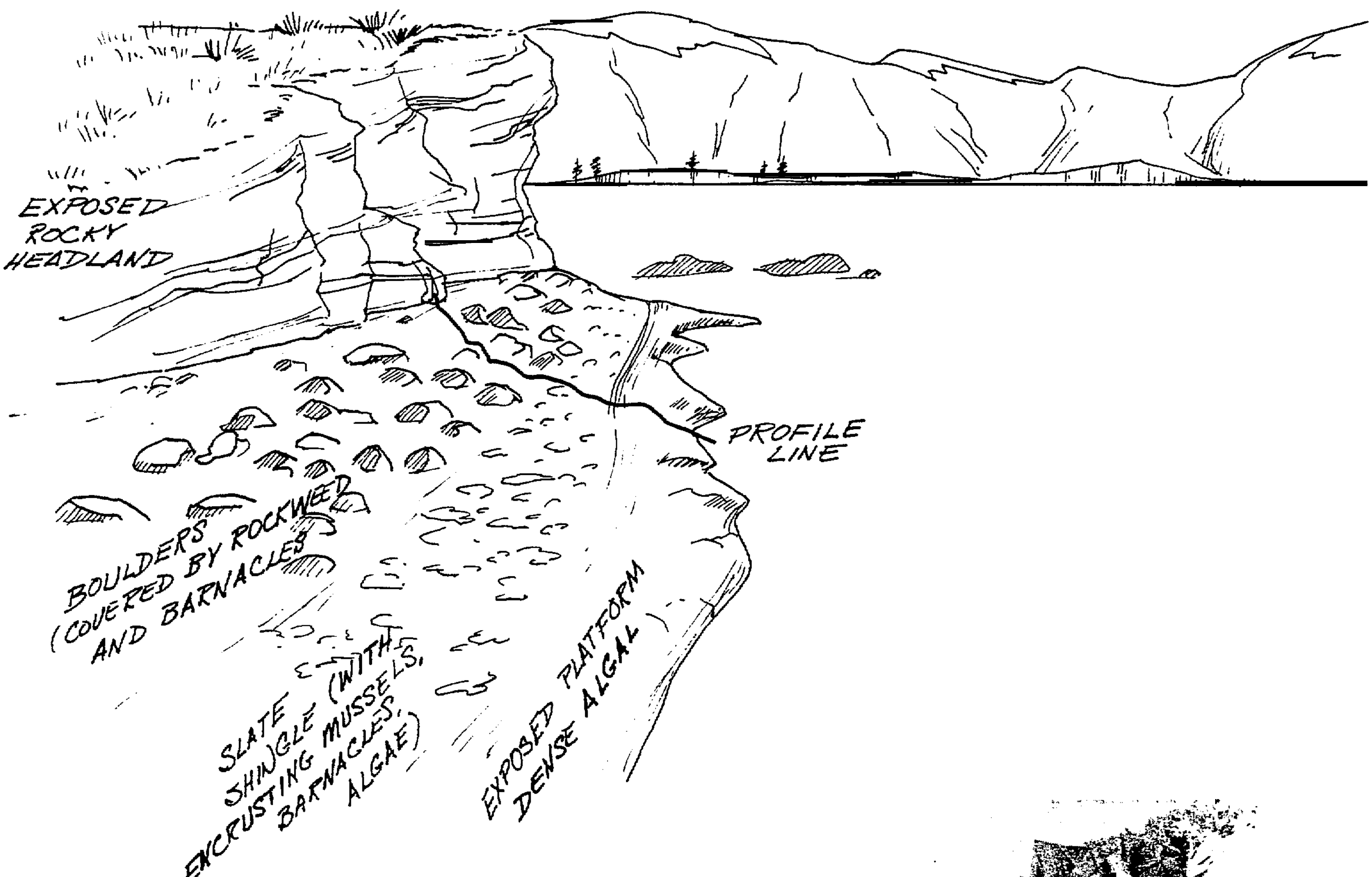
- Greatest impact would be to upper intertidal and tide pool organisms
- Oil persistence would be long-term because of low wave energy
- In cases of heavy oiling, mortalities would be great throughout the intertidal zone
- Removal of grazers and scavengers would result in increased algae productivity for the faster growing red and brown algaes
- Birds nest on sheltered rocky islands and can be contaminated in three ways:
  - Swimming in oiled waters
  - Landing in oil-calmed waters
  - Foraging among oiled rocks at low tide
  - Preening would result in ingestion

Recommended Cleanup Activity

- High pressure spraying may be effective
- Caution should be exercised in areas of high biomass

SKF-20

26 MAY, 1980



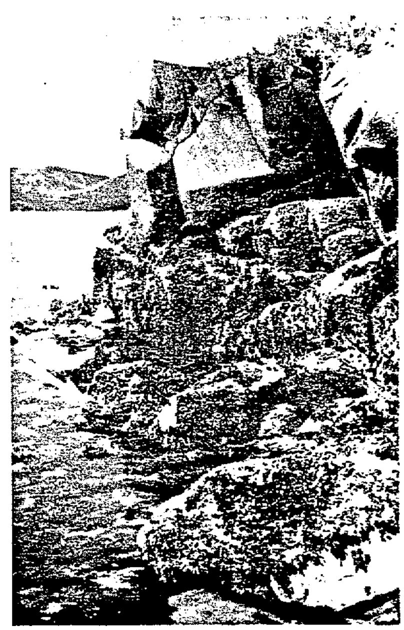


FIGURE 37. This ground view of protected rocky shore shows a broad zone of rockweed below a barnacle zone (see arrows). The delineation of zones is not as clear as in the exposed rocky shores (see ESI=1, Fig. 11). Rockweed is more abundant on the protected rocky shores than on the exposed rocky shores.

FIGURE 38. Ground view of typical sheltered rocky shore. With the exception of seasonal storm activity, these environments are seldom exposed to high-wave energy.

FIGURE 39. Ground view showing a steep eroding scarp fronted by angular boulders. Oil persistence would extend over several years, especially in crevices and between rocks and boulders. This photo was taken at mid tide. Note mussel zone at waterline and barnacle zone above it.

FIGURE 40. Close-up of rockweed zone on a sheltered rocky shore. Rockweed (Fucus distinchus) is the most common alga in the photo. The top arrow points to Halasaccion sp. and the bottom arrow to blue mussels (Mytilus edilus). The rockweed has a mucilaginous coating that helps protect the plant from oiling.

9) SHELTERED TIDAL FLATS

Description

- Physical
  - Composed of mud or silty sand
  - Sheltered from major wave and tidal activity
  - Usually located in back bay areas
- Plants
  - Flora are generally composed of patches of eelgrass
  - Mud flats are generally devoid of vegetation
  - Rockweed tends to grow on exposed rocks projecting from the mud flats
- Animals
  - Infauna are extensive; one polychaete species (Polydora) had counts of 200,000/m^2
  - Clam populations are extensive; butter clams were estimated at 354/m^2 based on 30-cm diameter samples
  - Other high-density clam species include softshell and Macoma clams
  - Many tidal flats are covered with extensive mussel beds
  - Many species of birds feed on tidal flats

Predicted Oil Behavior

- Long-term (several years) persistence of oil due to lack of wave and tidal activity
- Long-term oil incorporation into sediments is common
- Oil would be deposited primarily along high tide swash zones

Potential Biological Damages

- Extensive die-offs of infauna would be expected
- Mortalities would be caused by smothering and ingestion
- Oil would penetrate burrows, mixing in with sediment several centimeters below the surface
- Recovery could be slow; oil persistence would be long-term
- Stressed clams move to surface, attracting birds and other scavengers who can become affected
- Oiling of birds and ingestion

Recommended Cleanup Activity

- Where sediment is compact, manual and mechanical cleanup may be effective for massive accumulations
- Traffic over the flat should be limited

FIGURE 43. Aerial view of a large mixed sand and gravel tidal flat. Dark zones (arrow) along the perimeter of the flat are large mussel beds.

FIGURE 44. Ground view of tidal flat shown in Figure 43. In gravel and coarse-grained sand areas, large populations of butter clams were found. Twenty-six clams were taken from the hole in this photo.

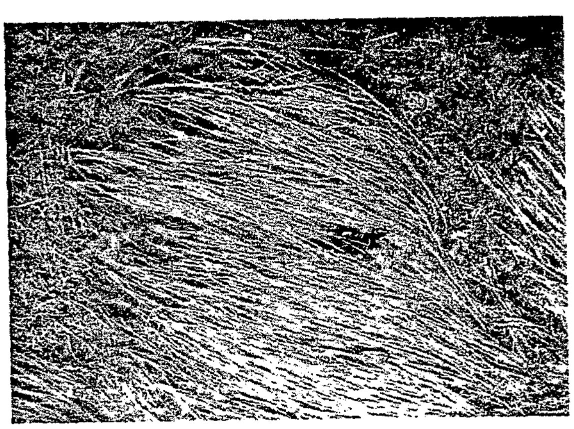


FIGURE 45. Eelgrass beds are sometimes located in tidal flat areas where water is retained. Most eelgrass beds were observed in protected, shallow-water inlets, or bays.

SKF-36
27 MAY, 1980

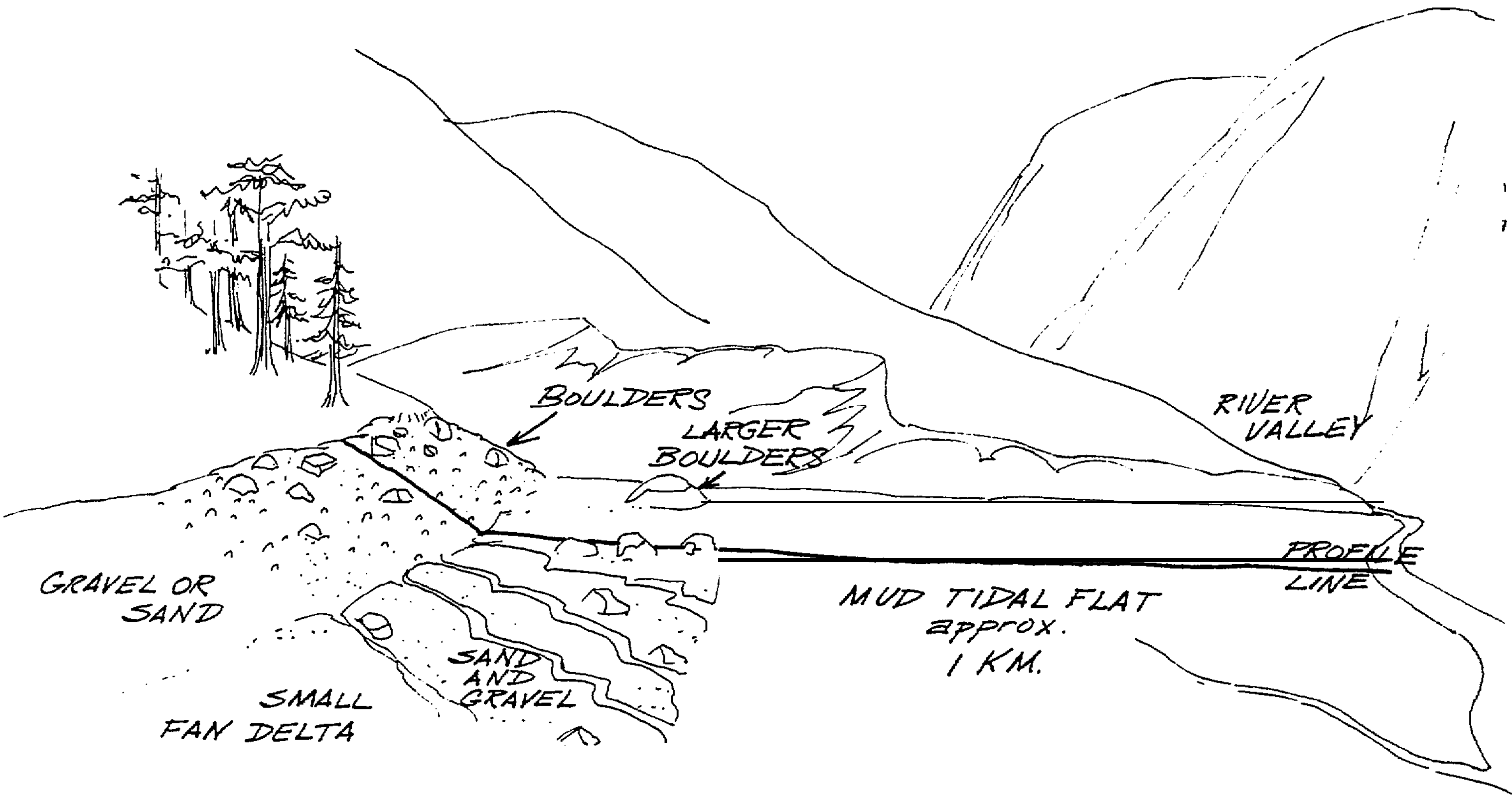


FIGURE 41. Aerial view of sheltered tidal flat. Most of these environments in the study area are located at the heads of bays. Sediments associated with these flats are commonly coarse-grained sand fed into the bay by numerous mountain streams.

FIGURE 42. Aerial view of a typical fine-grained sand, sheltered tidal flat. Oil would be deposited primarily along the high-tide swash zone.

10) MARSHES

Description

- Physical
  - Occur as narrow, fringing marshes or as broad areas within embayments
  - Well-sheltered from extreme wave and tidal activity
- Plants
  - primary vegetation is composed of halophytic grasses growing from the upper, mid intertidal zone to the supralittoral zone
- Animals
  - Infaunal and epifaunal organisms are sparse
  - Infauna consist of a few polychaetes and other burrowing organisms

Predicted Oil Behavior

- Long-term (5-10 years) persistence of oil is common with heavy accumulations
- Oil in small quantities would be deposited along outer fringe
- Oil in large quantities may cover entire marsh

Potential Biological Damages

- Oil would be persistent in sheltered marsh areas
- Long-term exposure to oil would damage marsh plants
- Epifaunal and infaunal organisms would be affected by long-term exposure to oiling

Recommended Cleanup Activity

- Under light oiling, the best practice is to let the marsh recover naturally
- During winter months, surface ice (when present) offers shoreline protection
- During early summer, cutting of oiled fringing grasses or low pressure flushing may be effective
- Vehicles and cleanup crews should avoid activity on marsh surface where possible

SS-10

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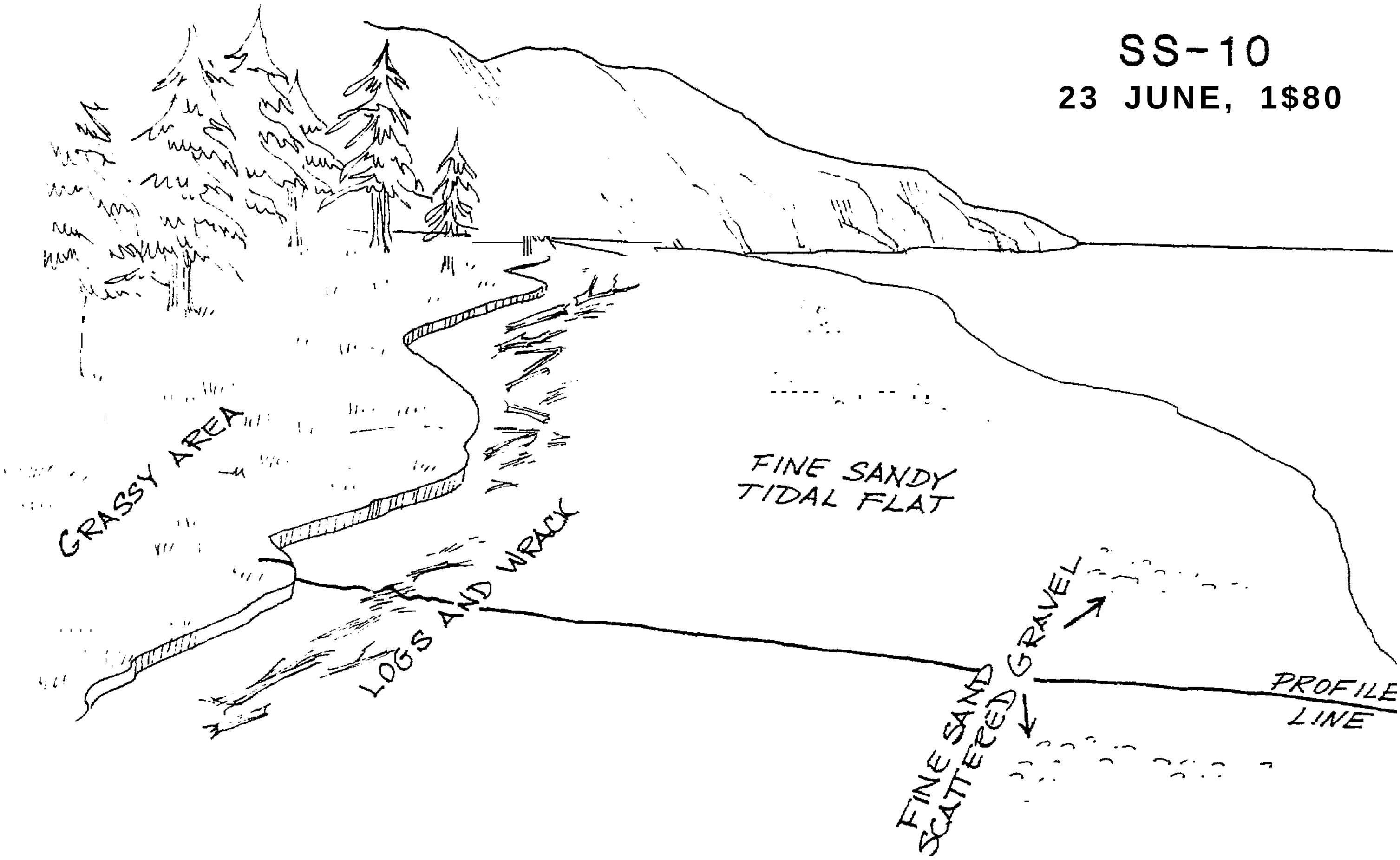

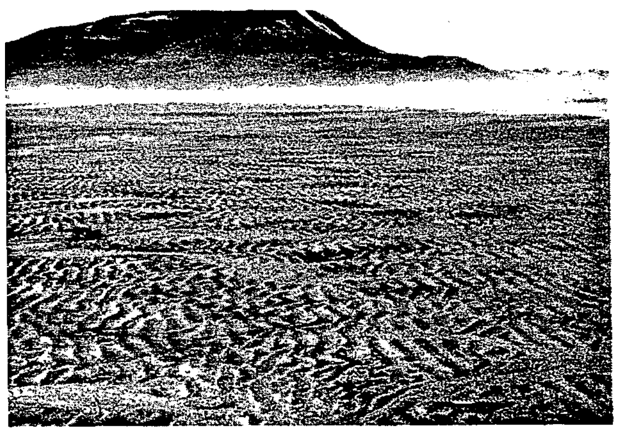

FIGURE 22. Ground view of exposed tidal flat on the Alaska Peninsula. Clams, polycheates, and burrowing crustaceans are common macroorganisms, but are commonly found in low to moderate populations.

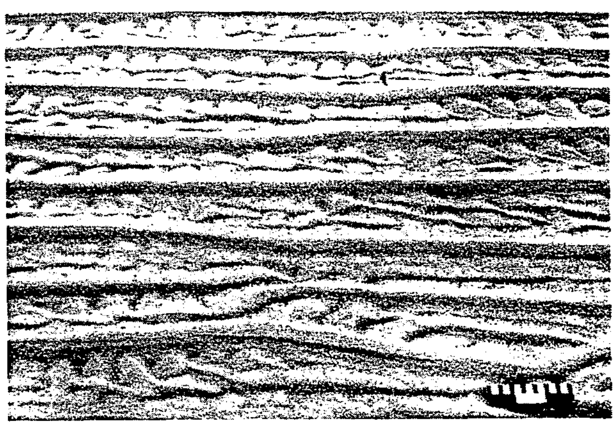

FIGURE 23. Close-up view of coarse-grained sediments on a tidal flat near SKF-49. The high mobility of sediments prohibits persistent accumulation of oil.

FIGURE 24. Exposed tidal flats front many coarse-grained sand and mixed sand and gravel beaches. This aerial view shows an exposed tidal flat and spit complex near a mixed sand and gravel beach.

FIGURE 25. Close-up view of typical coarse-grained sand and gravel sediments found on exposed tidal flats. Oil persistence and biological damage would be minimal in these areas.

CRITICAL SPECIES AND HABITATS

The Environmental Sensitivity Index (ESI) maps outline the location of critical areas in the study area with respect to oil spill impact. Location of feeding and breeding grounds of certain important species are also indicated.

This section presents four major groups of wildlife: (1) marine mammals, (2) marine birds, (3) finfish, and (4) shellfish. Summaries are given for major species present along with information concerning species distribution and the effects of oil.

MARINE MAMMALS

Resident Populations

• Harbor seals	(*Phoca vitulina*)	- Year-round; 16 major haulout and pupping areas.
. Northern sea lions	(*Eumatopias jubatus*)	- Year-round; five major haulout and pupping areas.
• *Sea otters	(*Enhydra lutris*)	- Year-round; scattered.

Visitors

• Harbor porpoises	(*Phocoena phocoena*)	Year-round; shallow bays and estuaries.
• Dan porpoises	(*Phocoenoides dalli*)	April-September; deep bays.
. Minke whales	(*Balaenoptera acutorostrata*)	- Occasional.
. *Humpback whales	(*Megaptera novaeangliae*)	- Occasional.
• Gray whales	(*Eschrichtius robustus*)	- Occasional.
• Killer whales	(*Orcinus orca*)	April to June; nearshore bays and coastal waters.

Protection Status

- All protected by Marine Mammal Act of 1972
- *Protected by Endangered Species Act of 1973

Predicted Impact

- Seals
  - Eye irritation (Geraci and Smith, 1976)
  - Already stressed seals (e.g., emaciated, late molting, captivity) may die from additional stress of oil contamination (Geraci and Smith, 1976)
  - Preweaned pups, which have not yet developed insulating fat layers, may have thermoregulatory stress
  - Greatest impact may occur during pupping season, when stress is high and preweaned pups are present
- Sea Otters
  - Totally dependent on fur for thermal protection
  - Any contamination may cause thermoregulatory stress, which can lead to death
- Whales
  - Stress may occur through ingestion of oil-contaminated food, oil intake through blowholes, eye irritation, and skin absorption
  - Baleen whales may have decreased feeding efficiency caused by matting of hairs on baleen plates, reducing filtering capacity (OSIR, 1980)

Recommended Response Measures

- Seals
  - Hazing from haulout areas during nonbreeding status
  - Boom protection of pupping areas with minimal human disturbance
- Sea Otters
  - Trapping and physical removal
- Whales
  - Hazing to change swimming pattern

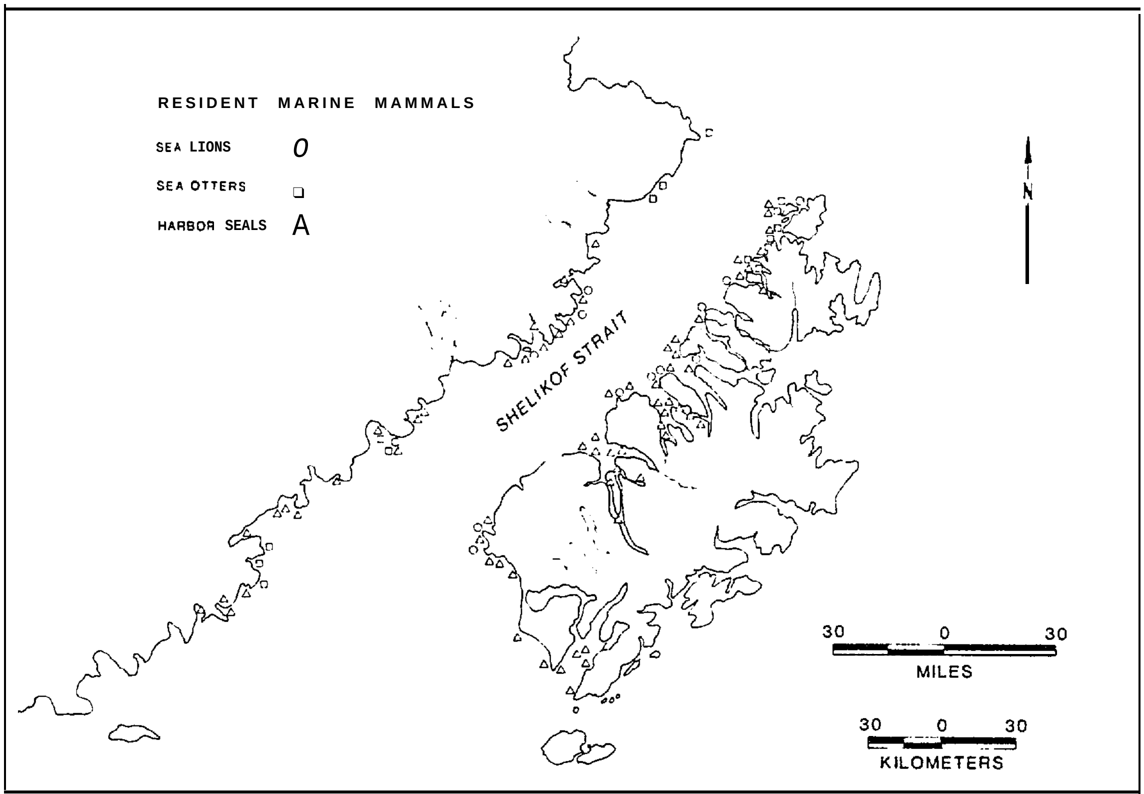

FIGURE 51. Diagram showing the distribution of resident marine mammals in the study area of Shelikof Strait.

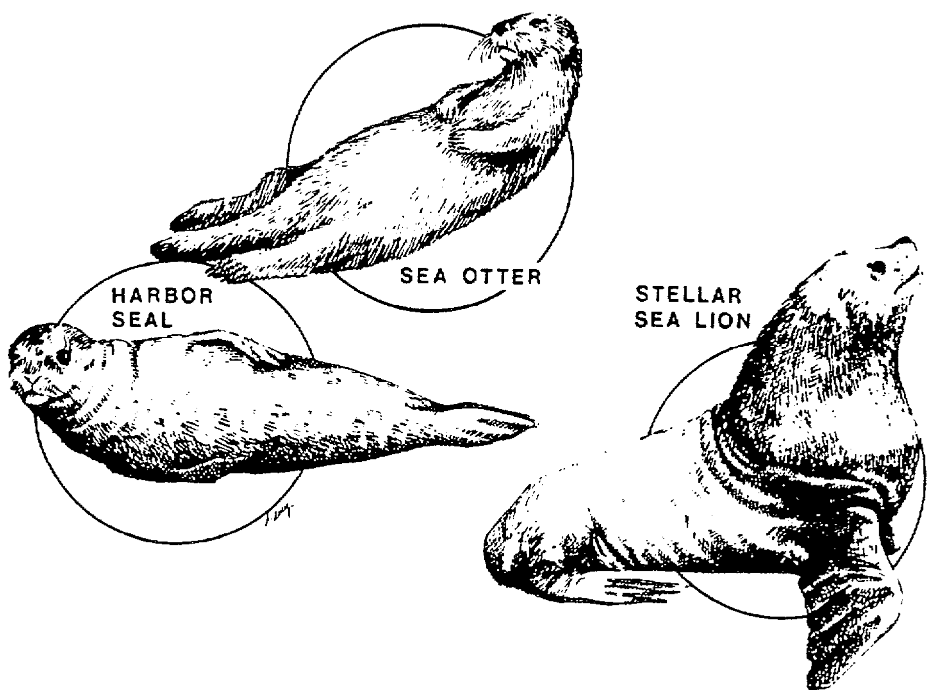

FIGURE 52. Sketches of resident marine mammals which are found in the Shelikof Strait area.

COASTAL MARINE BIRDS

Resident Populations

• Pelagic Birds		Year-round; offshore.
• Diving Birds-species of special concern:		
- Double-crested cormorant	(*Phalacrocorax auritus*)	Resident; coastal.
- Pelagic cormorant	(*P. pelagicus*)	Resident; coastal.
- Red-faced cormorant	(*P. urile*)	Resident; coastal.
• Waterfowl-species of special concern:		
- Emperor goose	(*Anser canaginus*)	Winters; coastal.
- Greater scaup	(*Aythya marila*)	Resident; coastal.
- Eiders	(*Somateria* sp.)	Resident; coastal.
- Stellar's eider	(*Polysticta stellari*)	Winters; coastal offshore.
- Harlequin duck	(*Histrionics histrionics*)	Resident; coastal.
- Old squaw	(*Clangula hyemalis*)	Winters; coastal to offshore.
- Scoters	(*Melanitta* sps.)	Winters; coastal.
- Buffleheads & goldeneyes	(*Bucephala* sps.)	Resident; coastal; migration.
- Red-breasted merganser	(*Mergus merganser*)	Nesting; migration.
• Raptors-species of special concern:		
- Bald eagle	(*Haliaeetus leucocephalus*)	Year-round.
- *Peregrine falcon	(*Falco peregrinus*)	Nesting; migration.
- Gyrfalcon	(*F. rusticolus*)	Resident.
• Shorebirds-species of special concern:		
- Black oystercatcher	(*Haematopus bachmani*)	Resident; intertidal.
• Gulls and Terns-species of special concern:		
- Glaucous-winged gull	(*Larus glaucescens*)	Resident; coastal.
- Mew gull	(*L. canus*)	Resident; coastal.
- Black-legged kittiwake	(*Rissa tridactyla*)	Nesting; offshore.
- Arctic tern	(*Sterna paradisaea*)	Nesting; offshore.
- Aleutian tern	(*S. aleutica*)	Nesting; offshore.
• Alcids-species of special concern:		
- Common murre	(*Uris aalge*)	Nesting; offshore,
- Thick-billed murre	(*U. lomvia*)	Nesting; offshore.
- Pigeon guillemot	(*Cepphus columba*)	Nesting; coastal to offshore.
- Parakeet auklet	(*Cyclorrhynchus psittacula*)	Nesting; offshore.
- Horned puffin	(*Fratercula corniculata*)	Nesting; offshore.
- Tufted puffin	(*Lunda cirrhata*)	Nesting; offshore.

Protection Status

- Migratory Bird Act
- Bald Eagle Protection Act
- *Endangered Species Act of 1973
- Migratory waterfowl regulations

Predicted Impact

- Pelagic Birds
  - May become contaminated at night when roosting on water
  - May attempt to feed in contaminated water
  - Because of pelagic nature, birds dying from oil contamination may sink to bottom or may be eaten
  - Impact would be difficult to determine
- Diving Birds
  - May dive or swim into oiled waters
  - Sometimes form large feeding flocks - these would be especially susceptible to mass oiling
- Waterfowl
  - Coastal species would be especially vulnerable
  - Emperor geese feed in sea grass flats, very shallow waters; may be oiled in water, or may be deprived of access to sea grass beds
  - Ducks dive for food and are found in coastal or offshore waters: contamination could result from swimming in oiled water; they may land in oil-calmed water for evening roost; they sometimes form large rafts which may result in massive oiling; they may dive through or surface in oiled water
- Raptors
  - Bald eagles feed on fish and seabirds; they may capture oil-weakened seabirds or contaminated fish for food
  - Peregrine falcons and gyrfalcons feed on waterfowl, shorebirds, and seabirds; they are attracted to weakened birds; they may feed on oil-contaminated prey
- Shorebirds
  - May feed or roost on oil-contaminated beaches
  - May ingest contaminated food
  - May ingest oil when preening contaminated feathers
- Gulls and Terns
  - Form large colonies on isolated islands or high cliffs when nesting
  - May attempt to feed in oil-contaminated water
  - Oil on feathers can be transferred to eggs
  - May roost in oiled water or on contaminated beaches
  - May ingest oil when preening contaminated feathers
- Alcids
  - Form large colonies
  - If disturbed, will fly from nests into water
  - May attempt to land in oil-calmed water
  - Escape behavior is to dive into water
  - May feed in oiled water

Recommended Response Measures

- Hazing of birds from oiled water may be effective
- During nesting season:
  - If still early in season, birds should be driven from rookeries and a watch maintained to insure that they do not return
  - If young in nests, attempts should be made to boom around colony: however, minor disturbances may drive adults from the nests
- Human disturbance should be kept to minimum
- Aircraft should not be operated over or near colonies

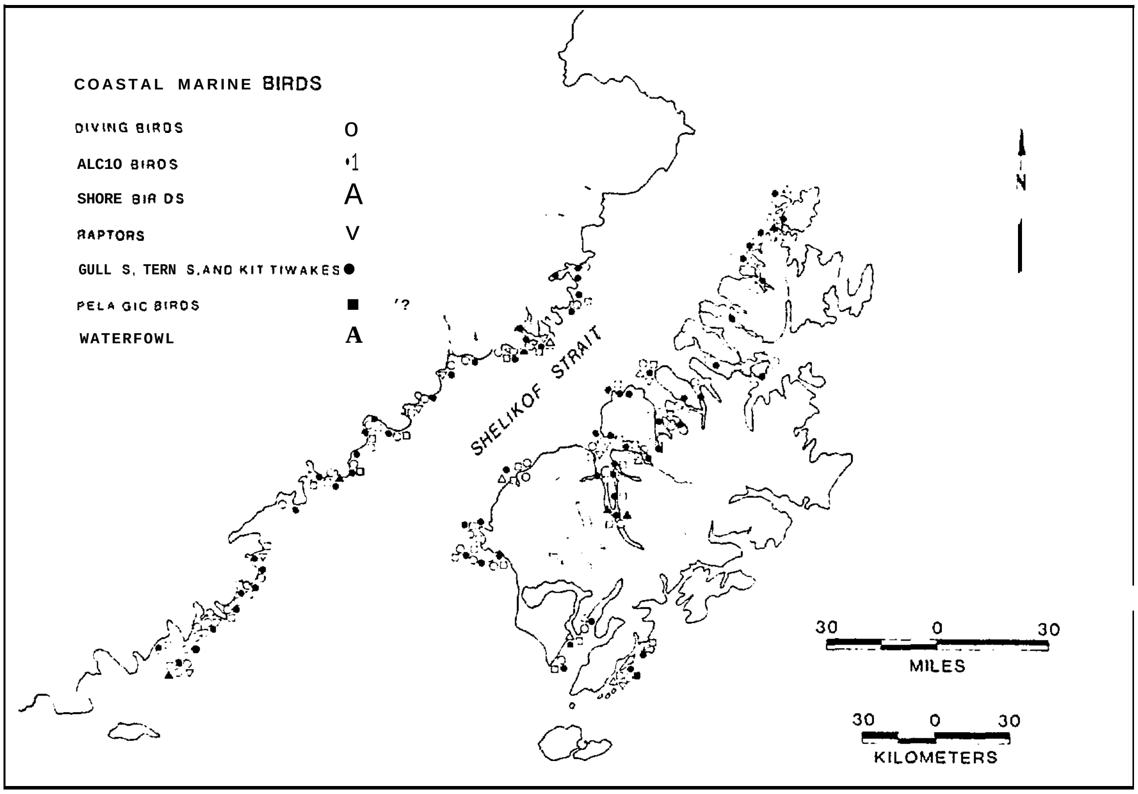

FIGURE 53. Diagram showing the distribution of coastal marine birds in the Shelikof Strait region.

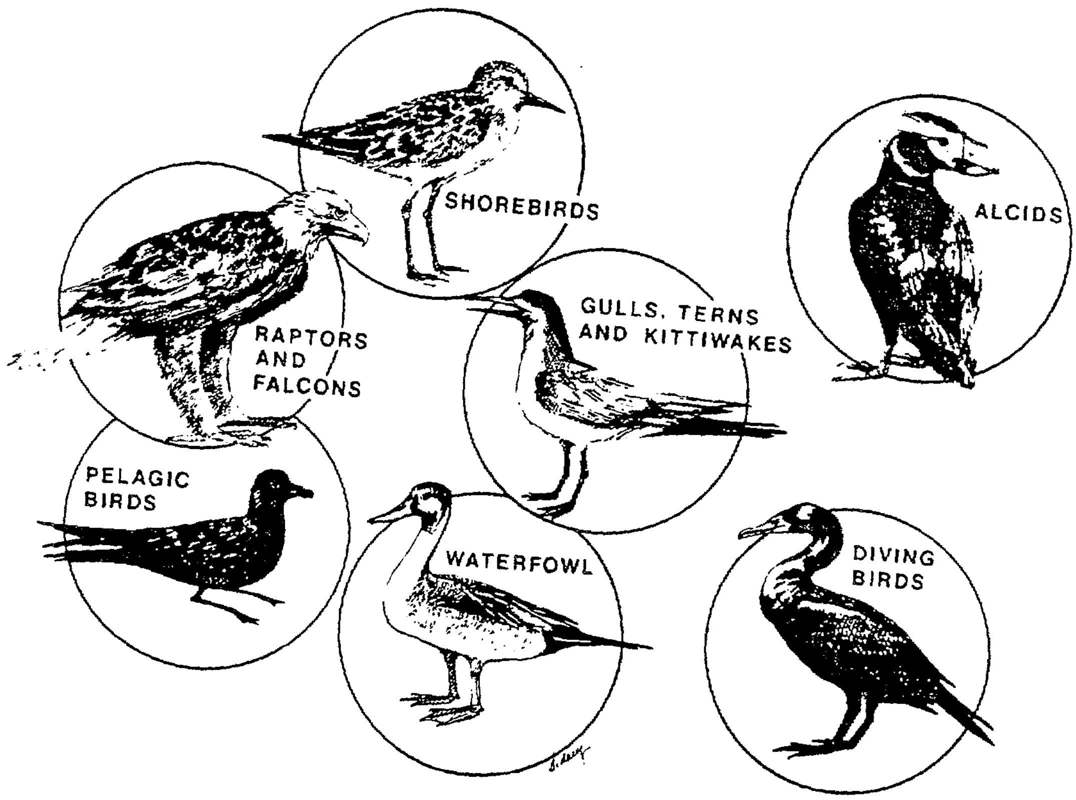

FIGURE 54. Sketches depicting coastal marine birds of Shelikof Strait.

FINFISH

Resident Populations

• Chinook salmon	(*Oncorhynchus tsawytscha*)	- Spring and summer.
• Sockeye salmon	(*O. nerka*)	- Mid spring to October.
• Pink salmon	(*O. gorbuscha*)	- Spring to fall.
. Chum salmon	(*O. keta*)	- Spring to fall.
. Coho salmon	(*O. kisutch*)	- Spring to November.
• Steelhead trout	(*Salmo gairdneri*)	- Year-round; peaks occur April-June (to sea), December-March (to freshwater), May-September (to freshwater).
• Pacific Herring	(*Clupea harengus*)	- Early spring to late fall.

Protection Status

- Salmon
  - Managed by State of Alaska and International Pacific Fisheries Commission
- Trout
  - Regulated by State Sport Law
- Pacific Herring
  - Foreign fisheries

Predicted Impact

- Salmon
  - All species susceptible during migration runs
  - Chum and pink utilize estuarine areas for egg-laying
  - Chum and pink also susceptible at egg, alevin, and juvenile stages
  - Homing mechanisms may be significantly affected by oil because they use sensitive chemical cues
- Trout
  - Susceptible to impact during migration
- Pacific Herring
  - Lay eggs on intertidal kelps and rockweeds
  - Adults would be impacted during nearshore egglaying process
  - Eggs attached to algaes would be sensitive to oiling
  - Larvae remaining in hatching area would also be sensitive to oiling
- General
  - Fish are sensitive to contamination from oil
  - Studies on eggs, larvae, and adults have been well-documented (Kuhnhold, 1972; Lachotowich *et al.*, 1977; Rice *et al.*, 1977; and others)

Recommended Response Measures

- Oil should be deflected away from major fish runs
- Openwater skimmers with paravanes should be used to remove oil before it strikes fish run areas

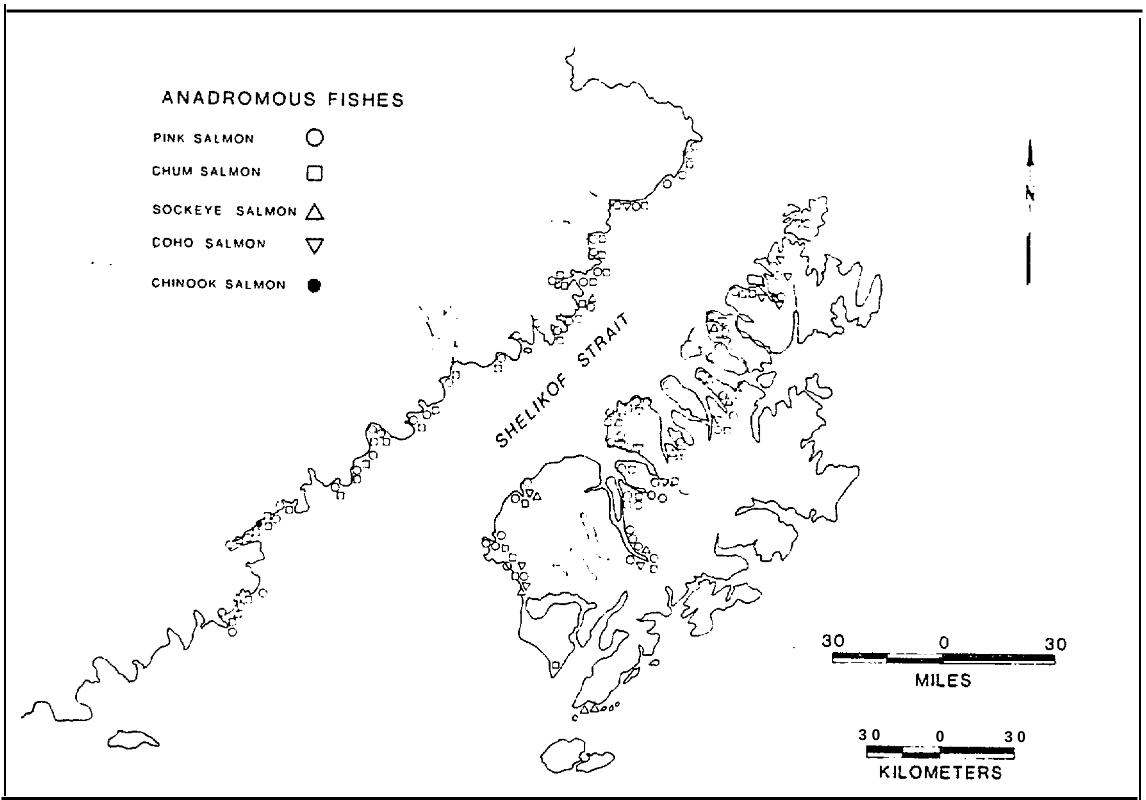

FIGURE 55. Diagram showing the distribution of anadromous fish along Shelikof Strait.

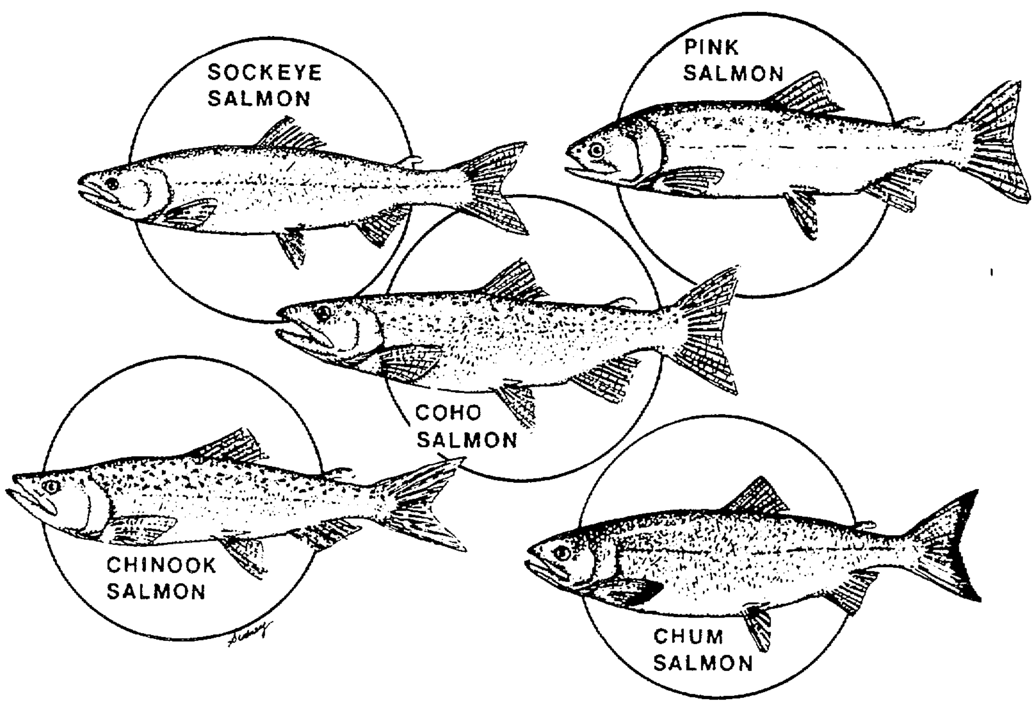

FIGURE 56. Sketches depicting anadromous fish along Shelikof Strait.

SHELLFISH

Resident Populations

• King crab	(*Paralithodes camtschatica*)	- Year-round.
• Snow and tanner crabs	(*Chionectes* sps.)	- Year-round.
• Dungeness crabs	(*Cancer magister*)	- Year-round.
. Razor clams	(*Siliqua patula*, *S. alta*)	- Year-round.
• Blue mussels	(*Mytilus edilus*)	- Year-round.

Protection Status

- High commercial value
- Regulated by State of Alaska

Predicted Impact

- King crabs
  - May be susceptible to oil in water column cluing planktonic stages
  - Juveniles are found in shallow, nearshore and intertidal waters
  - Often form "pods" of several thousand and would be highly susceptible if "pods" were in extremely shallow water
- Tanner crabs
  - Planktonic stages would be most susceptible to oil contamination
- Dungeness crabs
  - Those found in intertidal zone would be susceptible to oiling
- Razor clams
  - Inhabit exposed tidal flats; oil on exposed sand during low tide would flow down burrows and may be ingested by clams
  - Stressed clams move to surface, becoming more exposed to oil and predation
  - Planktonic stages would be exposed to oil in water column
  - High mortalities have been observed in several tidal flat oil spills (Blumer *et al.*, 1970; Hess, 1978)
- Blue mussels
  - Extensive beds were found throughout Shelikof Strait, either on rocky shores or in protected tidal flats
  - Impact to mussels on protected tidal flats would be extensive
  - Mussels on protected rocky shores would also be impacted extensively
- Death by asphyxiation or ingestion is likely

Recommended Response Measures

- Removal of oil from water surface by openwater skimmers
- Boom protection of sheltered tidal flats
- High and low pressure spraying may remove heavy oil accumulations
  - Though this would impact organisms present, it would prepare the substrate for future recolonization

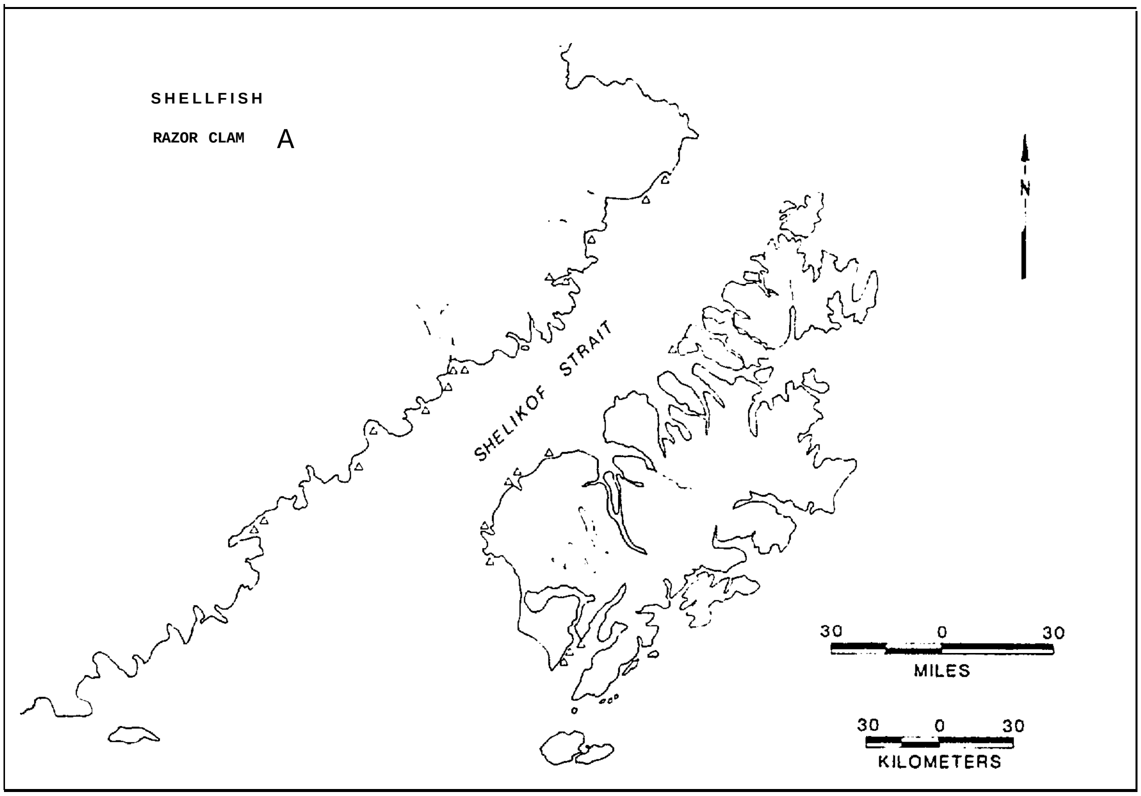

FIGURE 57. Diagram showing the distribution of razor clams throughout the study area of Shelikof Strait.

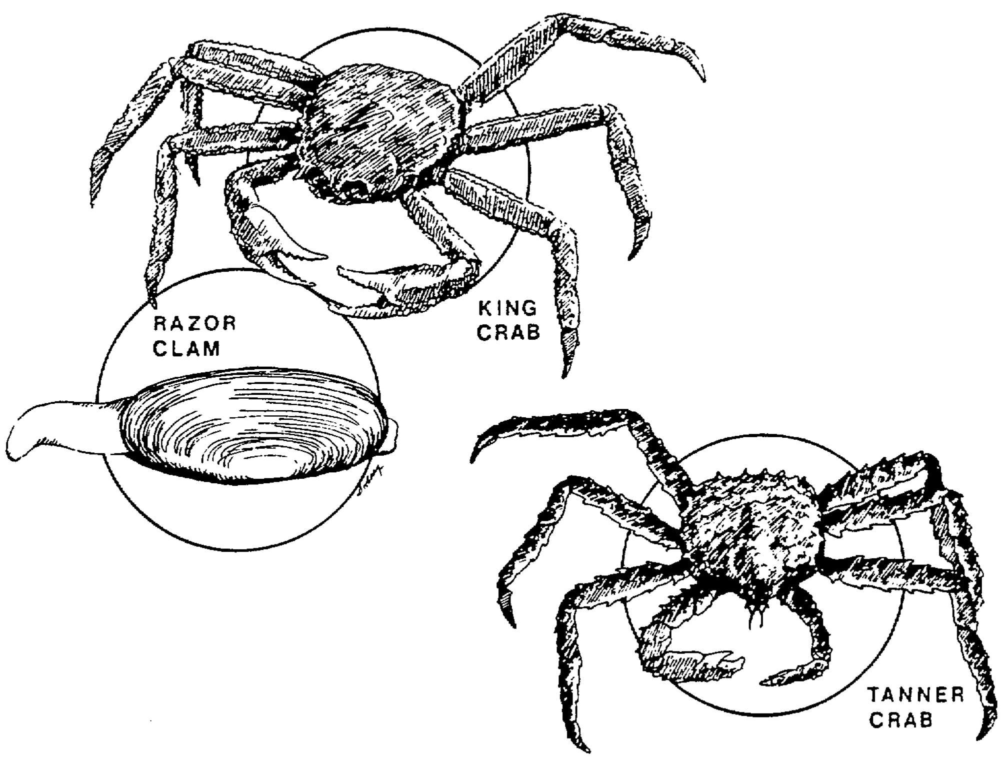

FIGURE 58. Sketches of valuable shellfish of Shelikof Strait.

Critical Intertidal Habitats

The shoreline habitats that rank highest on the ESI are salt marshes (10), sheltered tidal flats (9), and sheltered rocky shores (8). Therefore, these areas should receive the highest priority for protection in the event of an oil spill. Tidal flats are ranked lower (ESI=5, 7) on the index, dependent upon the density of the biomass present. The population numbers of biological communities are strongly controlled by exposure to wave and current activities.

Salt Marshes

Salt marshes comprise only a small portion of shoreline in the study area. The marshes encountered in the Shelikof Strait were of two varieties: (1) small marshes with well-defined tidal creeks, and (2) larger, laterally expansive, fringing marshes associated with sheltered tidal flats and deltas.

Salt marshes are considered the most sensitive habitat because long-term biological damage can result after oiling, especially where oil penetrates the roots of marsh plants and kills new growth, inhibits gas exchange, and/or alters sediment/microbial relationships. These effects may have a long duration (in some cases exceeding ten years), especially following multiple spillages of oil (Baker, 1971; Gundlach and Hayes, 1978b).

Sheltered Tidal Flats

Sheltered tidal flats found in Shelikof Strait are dominant at bay heads and are well-protected from extreme wave activity. They are usually composed of fine-grained materials but can range up to mixed sand and gravel in composition. These areas may have a large number of animals. Many species of clams inhabit the tidal flat (e.g., at one station over 250 butter clams/m^2 were observed) . When inundated, these flats support a variety of benthic and nektonic organisms such as crabs and demersal fish. During exposed periods, marine birds utilize the sheltered, tidal flat environments for foraging and resting.

Short-term or toxic effects of an oil spill on a tidal flat depend upon the duration of oil on the flat and its toxicity. Long-term or chronic effects are controlled by the binding of petroleum fractions within the sediment. In sheltered tidal flats, sediments may remain oiled for years and thus delay recolonization.

Sheltered Rocky Shores

Sheltered rocky shores are quite prominent throughout the study area, particularly in the back bay areas of the Kodiak Archipelago. These environments are dominantly sheltered from wave activity; however, occasional storms generate enough energy to periodically erode and transport large boulders and gravel present in these areas.

Sheltered rocky shores are ranked an 8 on the ESI scale because oil persistence would be great and biological damage would be severe in the event of oil spill impact. These environments host a high plant biomass and high species composition, diversity, and density. Barnacles, littorine snails, and mussels are common throughout the intertidal zone. Rich underrock and tide pool communities are also present.

Critical Subtidal Habitats

The ESI concentrates primarily on intertidal habitats; however, certain critical subtidal habitats are discussed. Particularly important areas are nearshore subtidal habitats which include seagrass beds and kelp (Figure 59; from Sears and Zimmerman, 1977).

Nearshore Subtidal Habitats

Numerous types of nearshore habitats are located adjacent to the intertidal habitats of Shelikof Strait. Habitats are controlled primarily by substrate which may include bedrock, gravel, sand, and mud. The subtidal substrate type may differ radically from the adjacent intertidal areas.

The functions of subtidal habitats vary considerably; however, some of the more important ones are:

1) Plant production.
2) Nursery areas for numerous species of fish (e.g., salmon, rockfish, greenling, and flatfish) and commercially important crustaceans (e.g., king, tanner, and dungeness crabs).

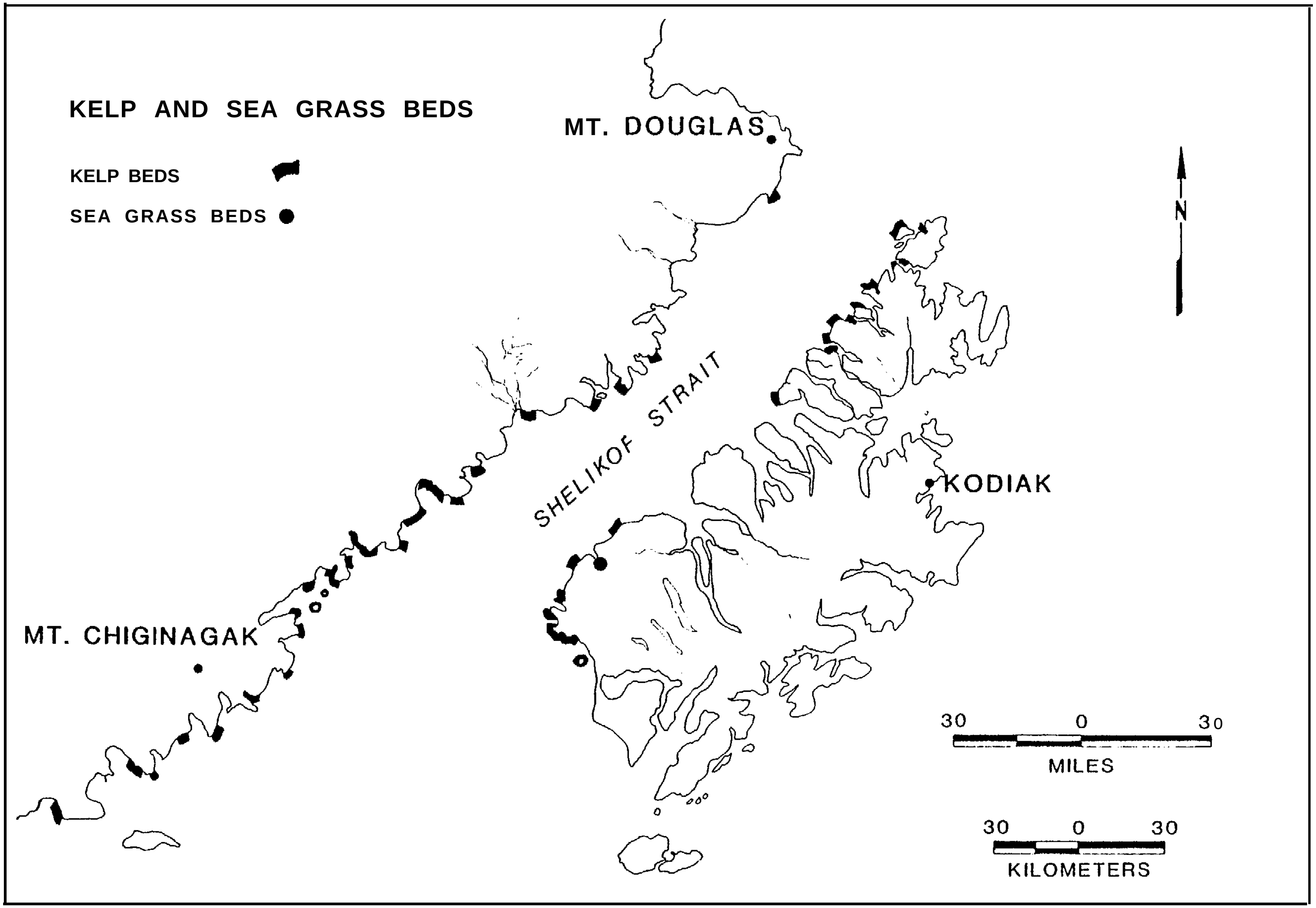

FIGURE 59. Diagram showing the distribution of subtidal seagrass beds in the Shelikof Strait area (after Sears and Zimmerman, 1977).

3) Forage areas for diving ducks (e. g., scoters and old squaw) and adults of several commercially important crab species.

The deposition of oil in nearshore subtidal areas has been observed at several major oil spills, most notably the AMOCO CADIZ (D'Ozouville et al., 1979). Avoidance by larger, more mobile organisms inhabiting these areas would reduce the impact of bottom oil. However, sessile or larval organisms are sensitive to such impact. Resulting mortalities would be difficult to determine since the fate of the carcasses would be unknown. Recovery of an impacted habitat is related to the rate of removal of oil from the substrate and the ability of the subtidal organisms to recolonize impacted areas. Unfortunately, no methods are available at present to directly protect these areas.

Seagrass Beds

Eelgrass (Zostera marina) assemblages typically occur on protected, lower intertidal and subtidal, soft substrates; and surf grass (Phyllospadix scouleri) assemblages occur in sediment deposits on exposed, lower intertidal and subtidal, rock substrates. Both types of plants are reported to have high primary productivity, and extensive beds can contribute significant quantities of plant material to intertidal and nearshore biological assemblages, and migratory birds such as black brant (Phillips, 1974). In addition, sea grasses provide important nursery areas for numerous fish, such as salmon and flatfish, and stabilize soft sediments.

McRoy (1968) summarized the location of numerous eel-grass beds in Alaska, but noted only three on the Kodiak Archipelago. Nybakken (1969) noted additional beds in Three Saints Bay. During this survey, numerous additional eel-grass beds were observed along the west side of Shuyak, Afognak, and Kodiak Islands; the largest of these beds was in Alitak Lagoon, north of Cape Alitak. The remaining beds, located mainly on tidal flats at the heads of bays, were small.

Sea grasses are true grasses rather than seaweeds. Thus, lacking a protective mucilaginous coating, they are susceptible to short-term effects from the impact of oil (Straughan, 1971; Diaz-Piferrer, 1962). However, if the sediments in which these plants root are not contaminated by oil, sea grasses are probably fairly resistant to long-term effects.

Kelp Beds

Rocky nearshore areas bordering Shelikof Strait appear to support large stands of canopy-forming and understory kelp. The major canopy-forming species are bull kelp (*Nereocystis leutkeana*) and a large, ribbon-like kelp (*Alaria fistulosa*). The major noncanopy species are *Laminaria*. Such beds can exhibit high annual rates of primary production on a unit area basis (Mann, 1972; Lees and Driskell, 1980; Lees et al., 1980).

Associated with the kelp beds are rich assemblages of infaunal and epifaunal invertebrates and demersal fish. Common components are sea urchins, starfish, snails, hermit crabs, hydroids, bryozoans, tunicates, rockfish, and greenling (Lees and Driskell, 1980; Lees et al., 1980). Kelp in Shelikof Strait probably would exhibit a moderate tolerance to oiling as a consequence of a mucilaginous layer coating most of the surface of the plants. Such tolerance to crude oil has been reported from numerous sites (Nelson-Smith, 1973).

DISCUSSION OF HABITATS WITH VARIABLE TO SLIGHT SENSITIVITY

Introduction

In addition to the highly sensitive habitats previously discussed, a wide range of additional habitats exists within Shelikof Strait. Rocky shores and beaches of various types show a wide range of sensitivity, depending primarily upon the degree of exposure of the habitat to wave action and tidal currents.

Exposed Rocky Shores

This habitat is subdivided into shores dominated by bedrock and boulders (ESI=1, 2). All types contain a solid substrate which provides attachment surfaces and, in many cases, crevices or underrock areas for microhabitats.

The dominant plant in the rocky, mid-intertidal zone is rockweed (Fucus distichus). Several other brown and red algae are also abundant. In the lower intertidal zones, Laminaria or kelp are dominant. Rockweed and kelp form dense mats of vegetation, which with crevices and undersides of rocks form an extensive shelter for small animals. Starfish, snails, barnacles, limpets, and mussels are common. Plants also provide protection from extreme temperatures and desiccation. Therefore, attached plants provide shelter, forage, and nursery value critical to rocky shore organisms.

Tide pools are a particularly sensitive portion of the rocky shore, especially if located in the upper intertidal zone. Oil-induced mortality could occur because of smothering or toxicity. Surface sheens may also block gas exchange. In this manner, a small spill in a tide pool may result in a localized die-off.

Many rocky shores attract marine birds and mammals for feeding or breeding. Avoidance may prevent oiling, but during nesting or pupping, oiling may lead to the death of eggs or young. Birds nesting on nearby cliffs may be attracted to feed on oiled rocky shores, thereby fouling their breast feathers and possibly their eggs. Mammals and birds feeding in oiled areas should be hazed due to the potential harm from ingesting oiled food items.

Beaches

Four beach types are defined in the ESI for this study area with fine/medium-grained sand beaches along exposed rocky shores being least sensitive (ESI=3), and coarse-grained sand (ESI=4) , mixed sand and gravel (ESI=6), and pure gravel beaches (ESI=7) with stable sediments being most sensitive.

Sediment size controls moisture and oxygen content of beaches, thereby influencing the abundance and distribution of plants and animals. Gravel and very coarse-grained sand fail to hold enough water to support abundant infauna, biomass, and diversity. Sand and mixed sand and gravel beaches afford some substrate suitable for burrowing organisms, but support only limited communities. In general, beaches are ranked low in standing stock biomass and diversity.

The sparse biological community found at most beaches may be subject to only a brief exposure to oil, especially on exposed beaches. Even if extensive mortality occurs, the readily cleansed substrate may recolonize within a year.

Exposed Tidal Flats

The exposed tidal flats identified in Shelikof Strait are associated with deltas or are located seaward of sand or mixed sand and gravel beaches. Substrate is commonly gravel but may vary to coarse-grained sand and silt.

Exposed tidal flats are ranked at two levels in the index (ESI=5 and 7a). The lower classification (ESI=5) is applied to tidal flats exposed to high wave and current conditions, possessing a variable range of species diversity and density as well as low population levels. The higher classification (ESI=7a) is given to exposed flats (similar species diversity and density as ESI=5) possessing increased population levels. The differences in population levels appear to be directly related to substrate type and mobility as well as variances in wave and current energies. In either case, persistence of oil would be low to moderate. Biological damage would vary with type and number of species present.

AREAS OF SOCIOECONOMIC IMPORTANCE

Socioeconomic information is included as part of the ES I so that areas of crucial importance to local coastal communities are identified for protection. Subsistence areas, mining claims, private property, archaeological sites, and coastal access areas are socioeconomic parameters identified for Shelikof Strait.

Mining Claims

Mining claims, mineral surveys, offshore mining claims, and prospecting lease areas having isolated claims are displayed as discrete sights. Areas having numerous claims abutting each other are designated en masse as a group claim or survey. The display of mineral sites is dependent upon the source used to map the claim location. No law exists requiring a mineral claimant to advise the United States of his or her mineral location. However, the recording of mineral claims is required under Alaska state law.

Shoreline claims are important for consideration during a spill. For example, contamination of the supertidal zone could prompt the decision for removal of contaminated sediments. If the decision maker was not aware of the claim status, valuable mineral-bearing sediments could be disposed of inadvertently, causing additional litigation problems.

Private Property

Private property (including native allocations) , timber and tidal leases, homesteads, and cabin sites are considered under this heading. Movement of manpower on these lands should not necessarily be prohibited for the purpose of reconnaissance. However, in some cases, prior notice for reconnaissance should be given, and permission obtained. Notice of cleanup operations to the owner is proper action in all cases.

Public Property

Public properties, including federal (also military lands) , state, municipalities, boroughs, and interagency lands, are indicated on the maps. Spills on these properties would involve immediate contact of the appropriate personnel in the governing body affected.

Archaeological Sites

Archaeological, prehistoric, and historic sites are of prime importance during a spill. Prior knowledge of the site location would eliminate mistaken excavation, trampling, or destruction of the locale or artifact. If it is suspected that a site has been oiled, the state historical society should be contacted before oil removal operations proceed.

Access Areas

Access points, including docks, harbors, landing strips, roads, and trails leading to the coastal areas, are graphically presented on the maps. These are of concern when moving workers or materials to the spill site with maximum efficiency.

In conclusion, the ESI maps are designed so that modifications and additions may be applied as necessary. Much of the Alaska land status information is in constant transition. It is suggested that updating of the maps should occur annually until the land status information is considered firm.

APPLICATION OF THE ESI

Introduction

The ESI is designed to be used as an integral component of Alaska's overall, oil-spill contingency plan. The geomorphic, ecological, and socioeconomic information presented in this text is synthesized onto 40 ESI maps which are presented in Appendix IV. The maps, used in conjunction with the text, provide the on-scene coordinator (OSC) with "fingertip" resource information to aid in extremely complex strategic and protection decisions, which must be made rapidly under spill conditions.

General Protection Strategies

In the event of a major oil spill, protection strategies must concentrate the limited equipment and manpower available to rapidly and effectively protect the most sensitive environments, In this discussion, defense strategies will be presented separately for exposed and sheltered environments in Shelikof Strait (Fig. 60) .

Exposed Areas

Much of the shoreline in Shelikof Strait is directly exposed to strong wave and tidal energies. This fact, coupled with the characteristics of a geologically immature shoreline, provide the framework for the following general protection strategies.

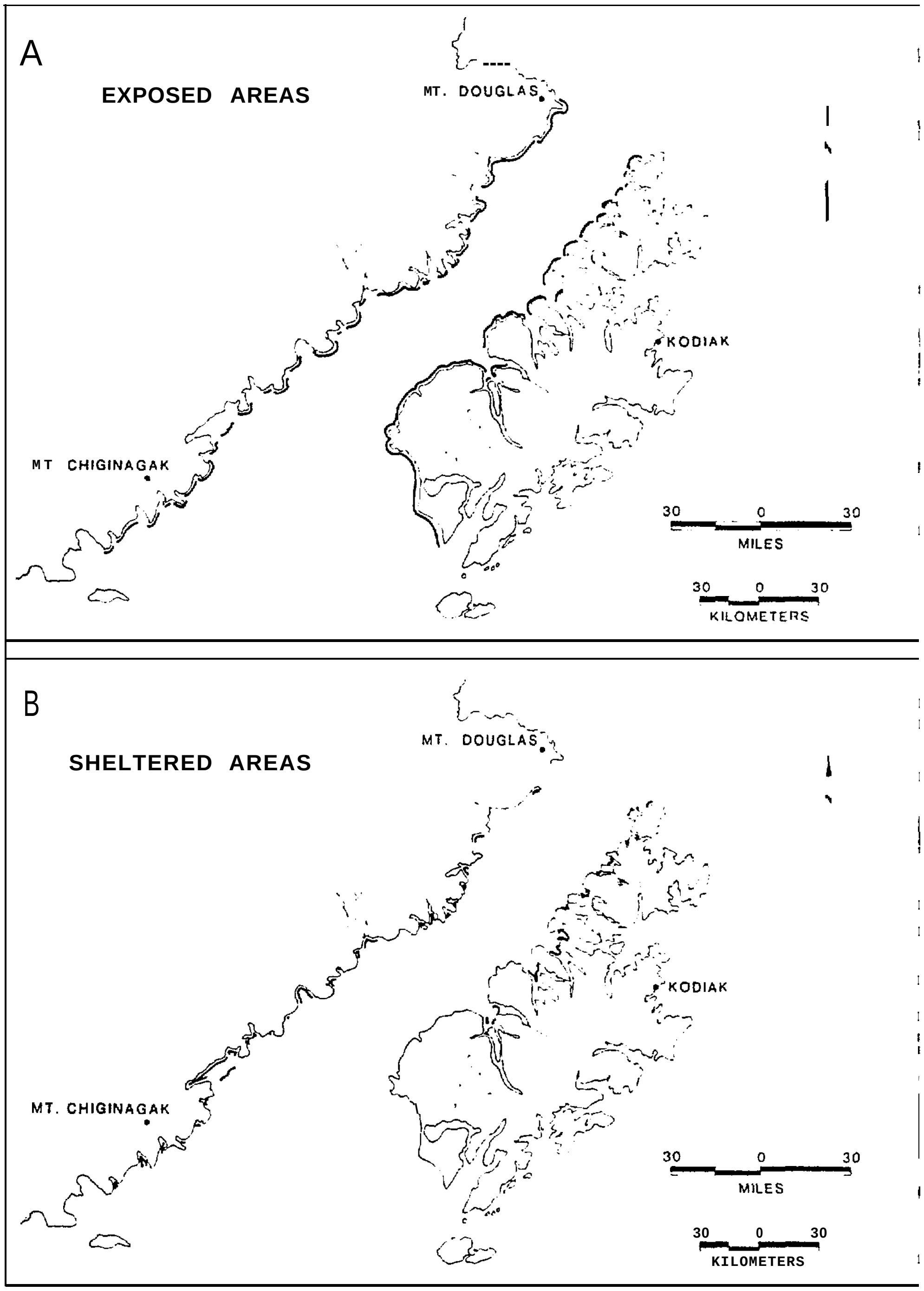

FIGURE 60. Maps showing the general locations of sheltered and exposed areas in the study area.

Higher energy environments (ESI=1 through 5) generally do not suffer long-term persistence of oil. Waves reflecting off exposed rock scarps tend to hold oil offshore. In areas where oil does deposit, subsequent wave action tends to quickly remove it. For example, Dark Island (located in the northern Kodiak Archipelago) hosts a variety of environments ranging from an exposed rocky headland (ESI=1) to a sheltered rocky headland (ESI=8). Limited equipment and manpower would be focused best on protection of the sheltered rocky shore where biological damage would be severe and oil would persist for years. The exposed rocky headland would receive minimal biological damage, and oil would be removed naturally in a short time.

Unfortunately, the extreme tidal range and typical sea conditions of Shelikof Strait do not facilitate the use of common mechanical protection techiques (i.e., booms, skimmers). Wherever possible, inlets opening to sheltered environments should be closed by infilling (indicated on maps). Hazing techniques may be used to keep certain species of wildlife, particularly birds, away from oil-impacted areas. Although controversial, the use of chemical dispersants should not be ruled out as a viable aid to conventional protection techniques.

Sheltered Areas

Unlike the environments described in the preceding section, the coastal environments located in sheltered areas (ESI=8 through 10) are not exposed to high wave energy.

Consequently, rich biological communities are present and there is longer-term oil persistence. These areas, shown in Figure 60, are distributed throughout the study area and require special protection consideration.

Extreme tidal range prohibits the use of many conventional protection techniques in sheltered areas. However, sea state is usually much calmer in the back bay waters, and the use of offshore containment booms and seagoing skimmers may be feasible. The few inlets present in these areas cannot be effectively boomed, but closure by infilling may be practical for protecting smaller, sheltered tidal flats and marshes.

Further, the ESI maps indicate the areas most likely to be damaged by oil; they do not outline specific protection strategies. To prepare a truly effective spill response program, priority protection areas should be designated by the regional response team (RRT). Once designated, detailed studies (including bathymetric and hydrographic surveys) should be conducted to determine specific defense strategies for protection.

In developing oil spill response plans, it is important to decide cleanup approaches before spill occurrences in order to give the OSC guidance. Priorities for cleanup of recreational areas should be determined beforehand. During the IXTOX I oil spill in Texas, the scientific-support community recommended that beach cleanup be limited to recreational areas and not be extended to the other 200 km of uninhabited shoreline. If recommendations such as these were decided beforehand for particular segments of shoreline (e.g., subsistence areas), response to a major spill would be quicker and more organized. Cleanup equipment could then be planned for and stockpiled at critical habitats.

Finally, it is recommended that the ESI maps be updated periodically. Socioeconomic, geomorphic, and biological considerations will alter as Alaska’s coastal zone develops, and these changes should be noted.

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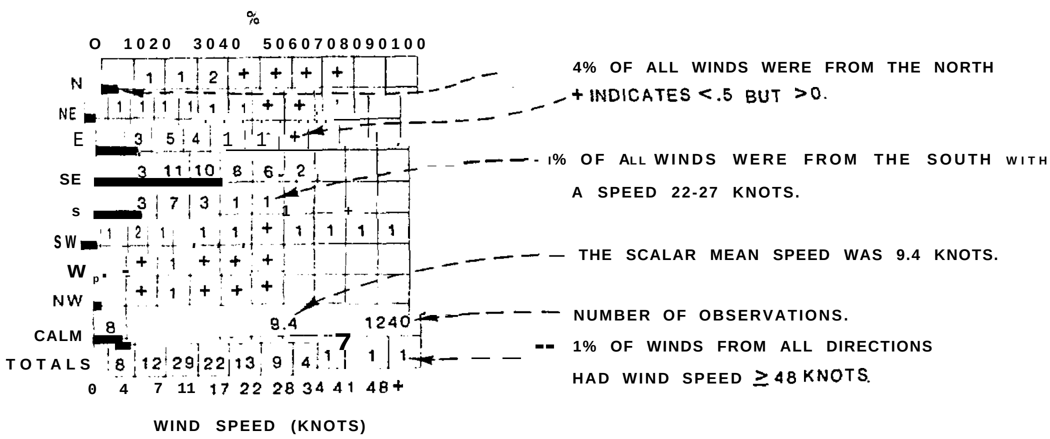
APPENDIX I

SUMMARY OF CLIMATOLOGICAL AND OCEANOGRAPHIC INFORMATION

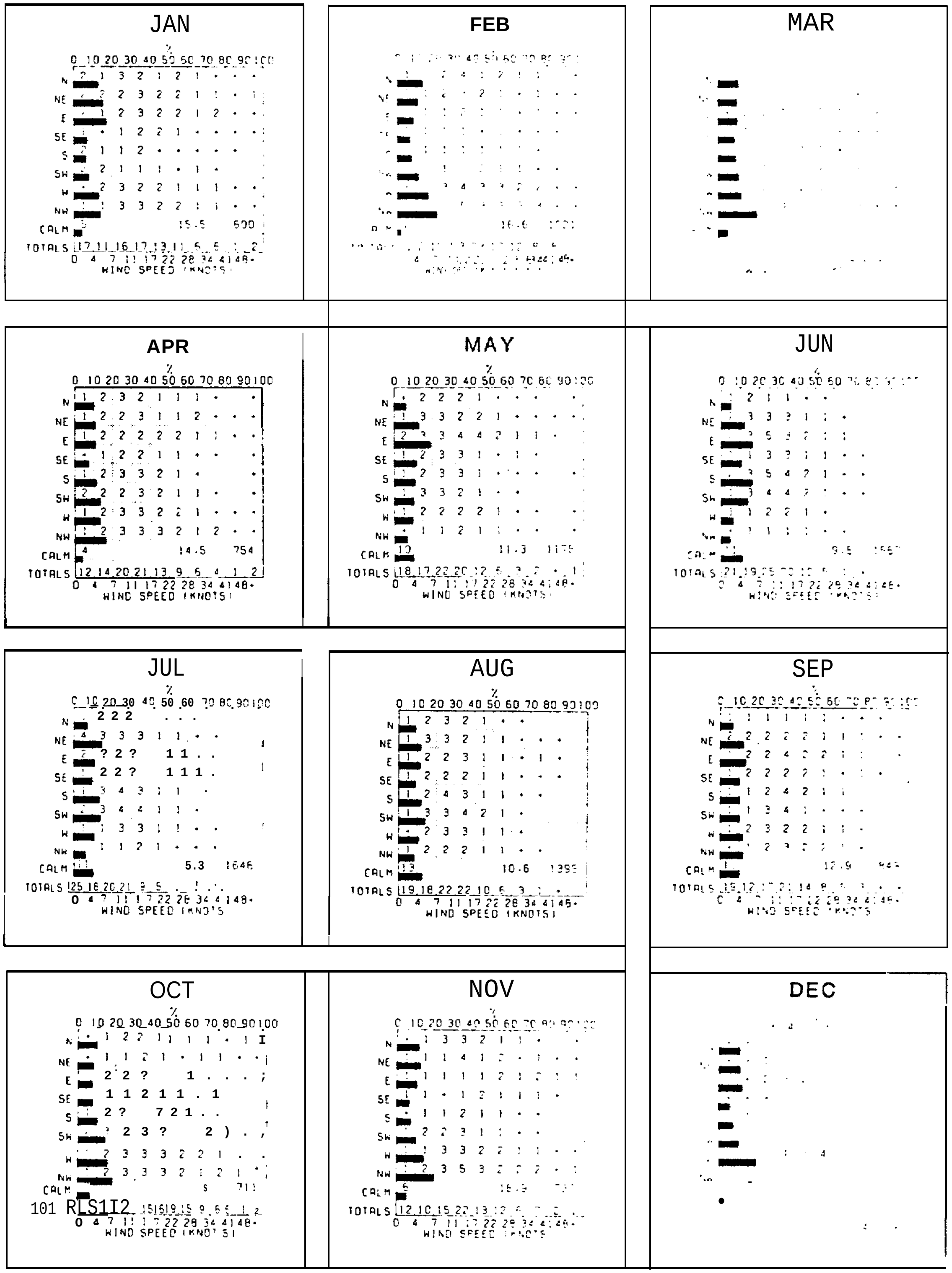
WINDS

Data on wind speed and direction of approach for Shel - ikof Strait. Winds in the study area are characterized by variable velocities and approach direction with only a weak, seasonal pattern emerging. In winter, dominant approach is from the west, swinging northerly until late spring. Ap- proach is then weak easterly and southerly until late fall, but these patterns are especially indistinct. The winds in this area are dictated by storm activity moving into the Gulf of Alaska, and probably are funneled through the strait. Data from AEIDC, NCC (1977a, b).

DIRECTION FREQUENCY TOP SCALE: BARS REPRESENT PERCENT FREQUENCY OF WINDS OBSERVED FROM EACH DIRECTION. SPEED FREQUENCY BOTTOM SCALE: PRINTED FIGURES REPRESENT PERCENT FREQUENCY OF WIND SPEEDS OBSERVED FROM EACH DIRECTION.



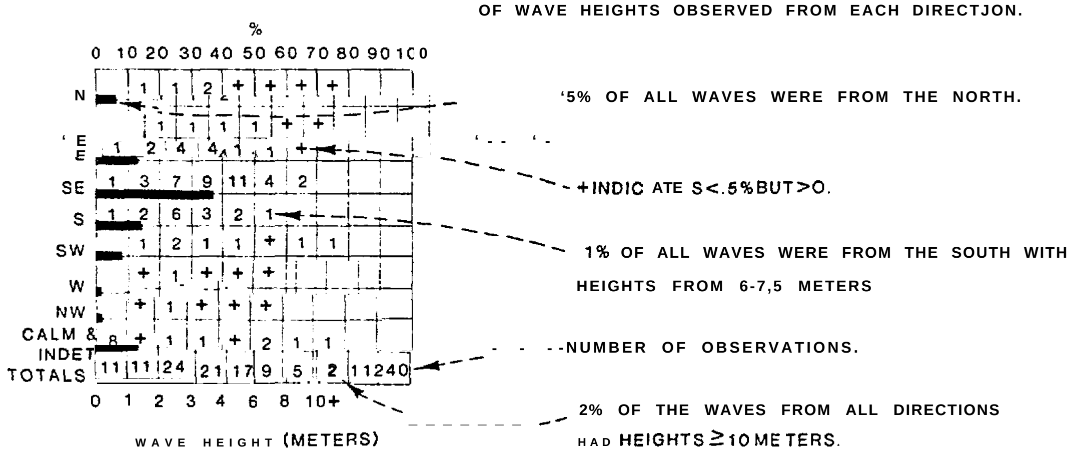
WIND SPEED AND DIRECTION



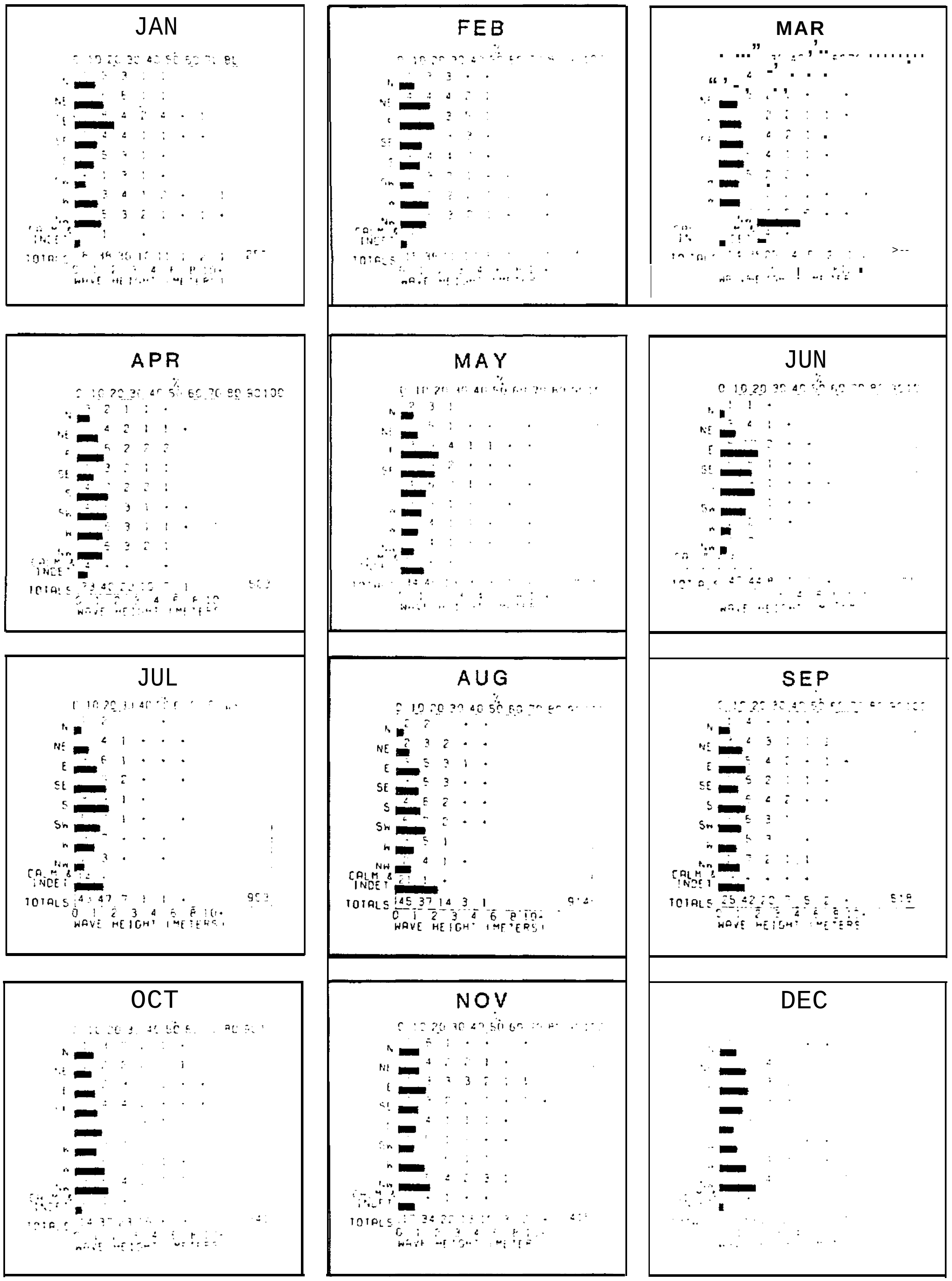
WAVES

Wave height and approach direction data for the Shelikof Strait region. Strong trends are not present in these data; however, general approach dominance is from the southeasterly quadrant in the summer. Winter waves approach most commonly from the east-northeast and west. Easterly waves are probably generated by storms which move up low pressure troughs and stagnate in the Gulf of Alaska (Nummedal and Stephen, 1976). Westerly waves are probably also storm-generated, as wave height maxima are associated with this approach direction. Data from AEIDC, NCC (1977a, b).

DIRECTION FREQUENCY TOP SCALE: BARS REPRESENT PERCENT FREQUENCY OF WAVES FROM EACH DIRECTION.
HEIGHT FREQUENCY BOTTOM SCALE: PRINTED FIGURES REPRESENT PRECENT PERCENT FIGURES FREQUENCY OF WAVE HEIGHTS OBSERVED FROM EACH DIRECTJON.



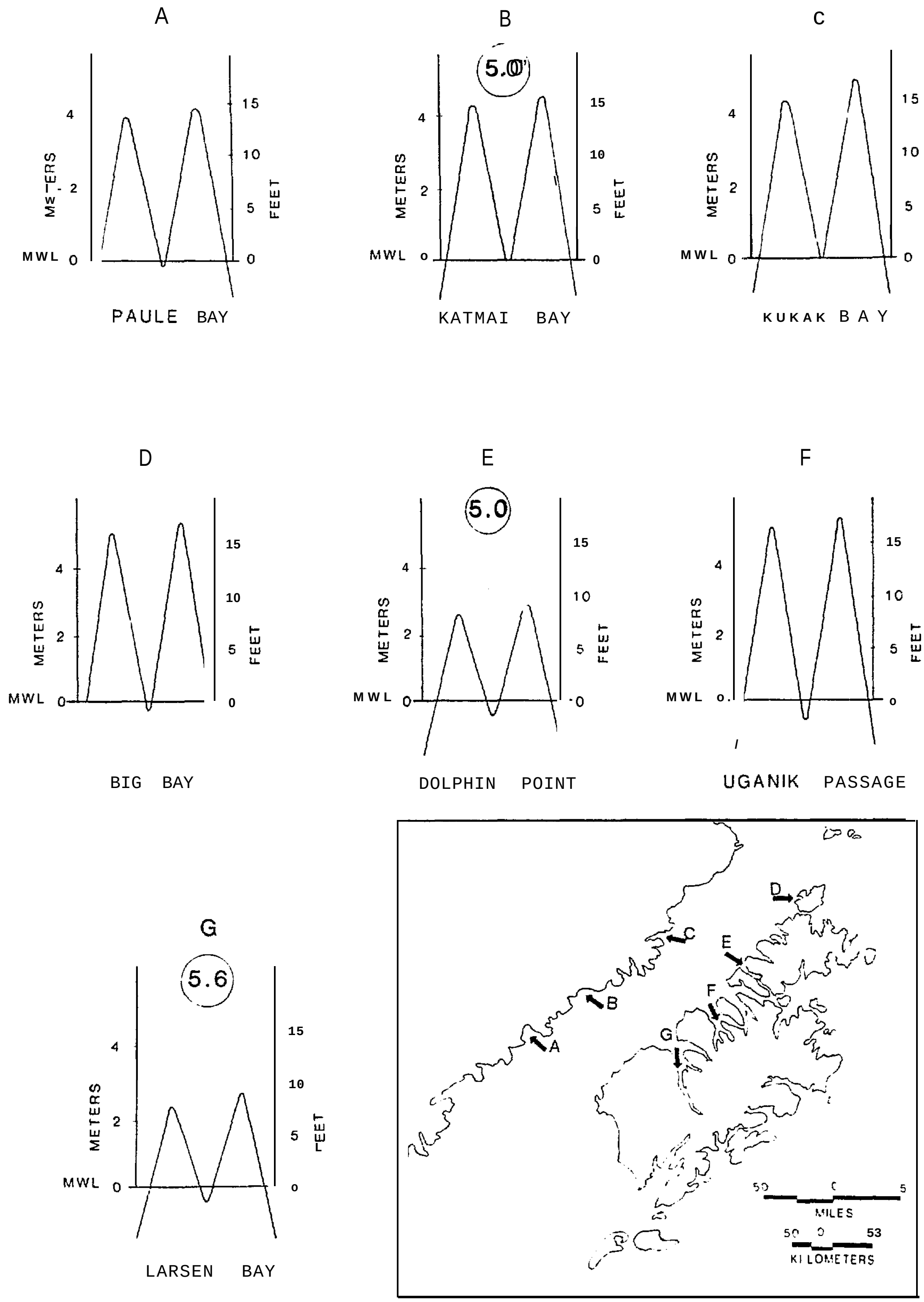
WAVE HEIGHT AND APPROACH



TIDAL CURVES

Maximum-predicted, daily, spring tidal curves for various locations in the study area. Maximum-predicted, high-tide levels (in meters above mean sea level) are shown for selected areas in circles. All tides are semidiurnal mixed. The Alaska Peninsula side of Shelikof Strait is characterized by a higher tidal range (6.0-6.5 m; 19.7-21.14 ft) than northwestern Kodiak and Afognak Islands on the opposite side (4.0-4.7 m; 13.2-23.0 ft). Data from AEIDC, NCC (1977a, b).

MAXIMUM PREDICTED TIDAL RANGE

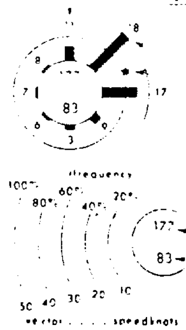


MAXIMUM PREDICTED HIGH TIDE

LOW-PRESSURE CENTER MOVEMENTS

Low-pressure center movement roses for the study area and expected storm tracks for the ice-free season (May to November). Storms generally originate from the southwesterly quadrant for all areas and are more common during the later part of the season before freeze-up. Most major storms track into the Gulf of Alaska with a few splaying off toward the eastern Bering Sea coast in summer and fall. Data from AEIDC, NCC (1977a, b).

Legend



Low pressure center movement

12 hour movements of low pressure centers considering only closed circulations

Mean speed: Printed figure at the end of each bar represents the mean speed of movement in knots toward the indicated direction

low pressure centers moving toward the N had a mean speed of 11 knots

Direction frequency: Bars represent percent frequency of 12 hour movements toward each direction. Each circle represents 20

41 of all 12 hour movements were toward the NE

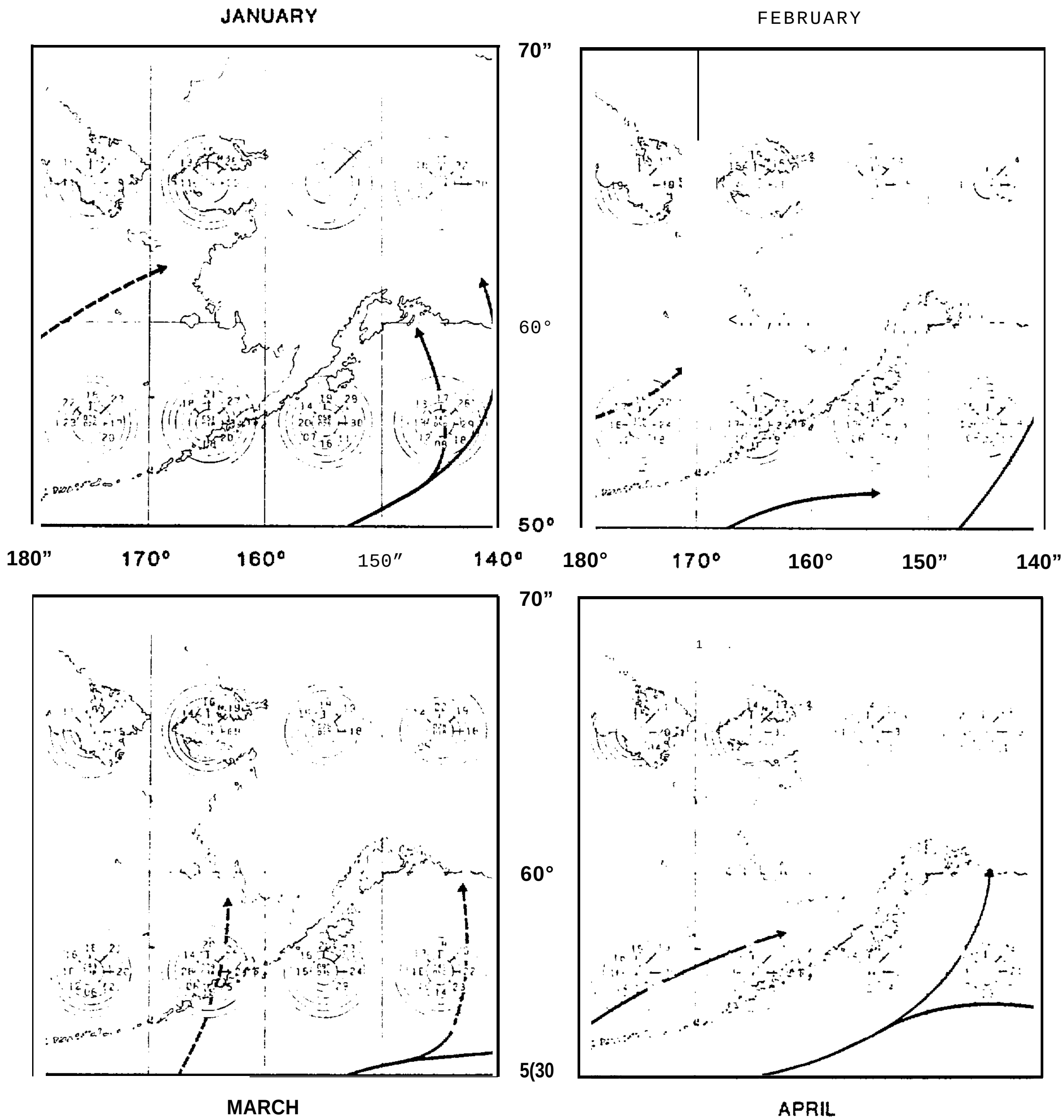
Vector mean direction and speed: Dot indicates mean vector movement. Each circle equals 10 knots

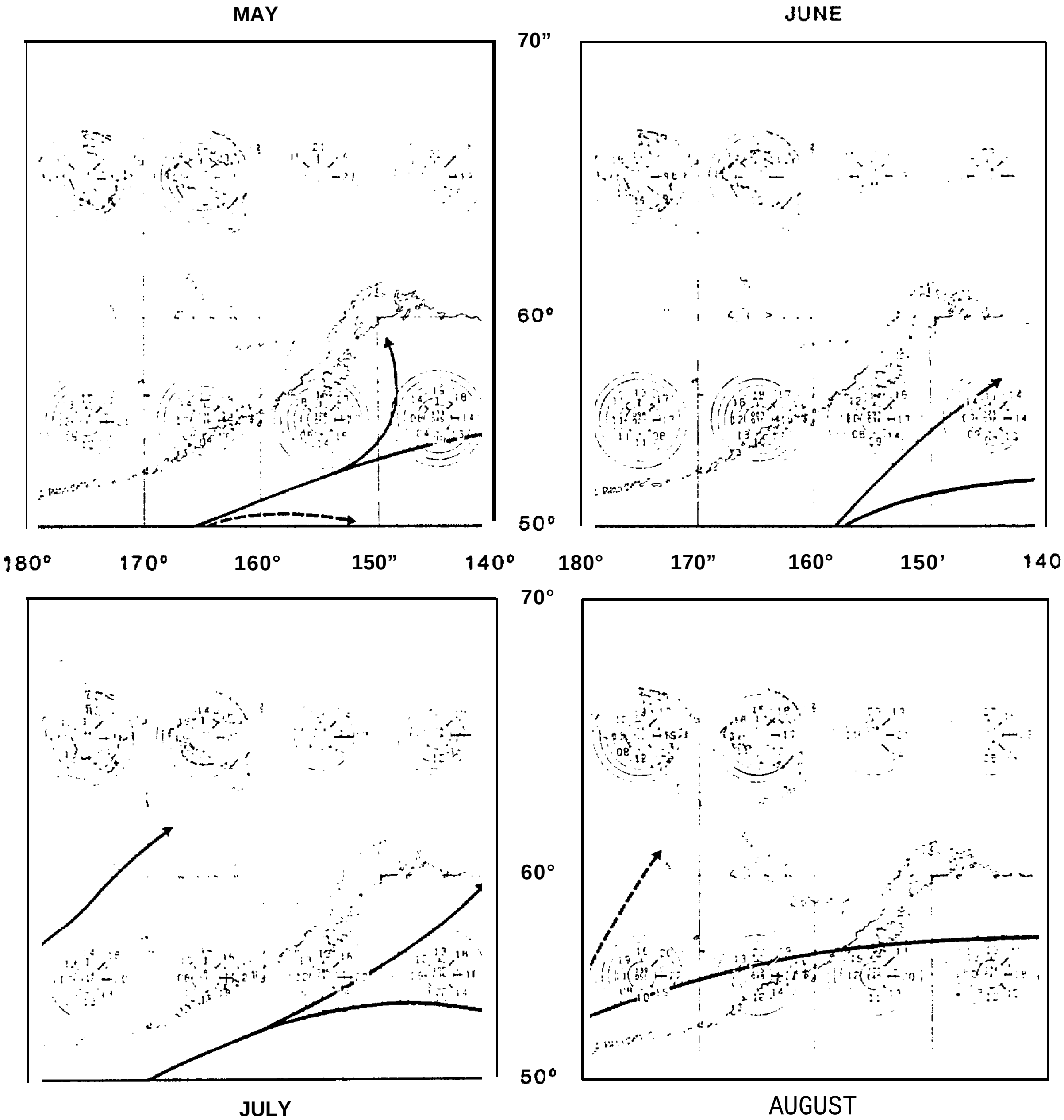
Mean vector movement of all centers was toward 70 at 12 knots

Statistics for this rose are based on 177 twelve hour movements

83 low pressure centers were observed in the 10 X 10 area during the 9 year period of record 1 66 12 74

BLACK ARROWS: Preferred storm tracks solid In. primary tracks dashed for secondary tracks

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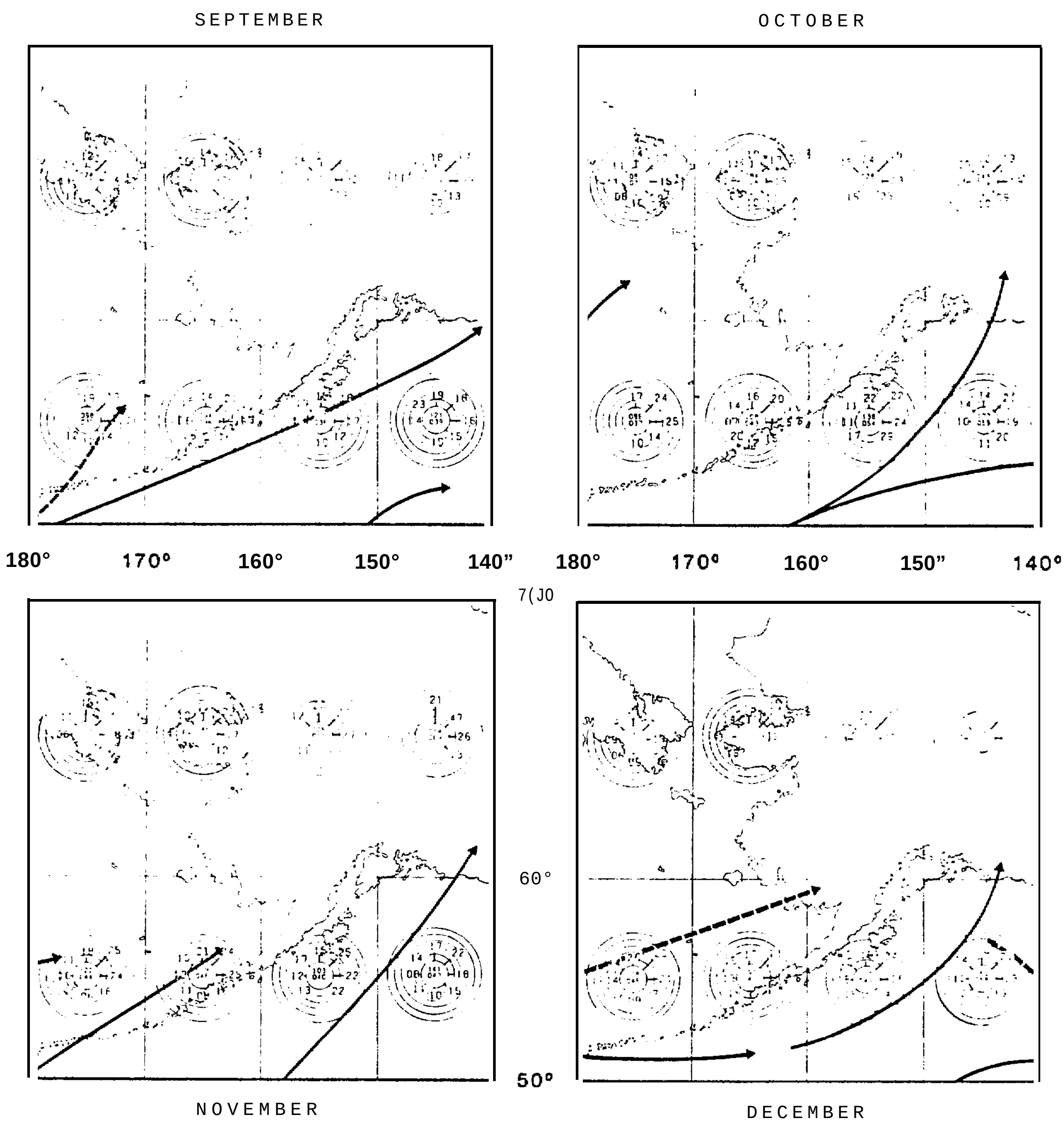
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APPENDIX II

STATION DESCRIPTIONS

SKF-1: Located on western shoreline of Dark Island! this station is a very small, elastic, pocket beach perched on a wave-cut platform cut into granodiorite bedrock mixed with green schist. The upper portion of the profile has a grassy knoll covered with a thin soil profile approximately L m thick. Next is a small scarp 20-50 cm high which extends to the beach face. At the top of the beach face is a narrow zone of coarse cobbles and gravel which are very poorly sorted with mixed fine to medium gravel. At the base of the upper beach face, this zone intersects the rock platform which is covered with boulders and cobbles. The boulders and cobbles represent a thin veneer perched on top of the rock platform. The central portion of the beach is occupied by outcropping bedrock, and the lower portion has fairly uniform, very coarse gravel to cobbles one or two layers thick, covered by a fairly thick growth of fucus and extremely abundant littorina.

The general biological setting is a wave-cut platform. Zonation is divided into terrestrial vegetation, a wrack, a lower to middle intertidal zone, and a lower to subtidal area. Organisms in the debris consisted mainly of Nereocystis, and the lower intertidal was dominated by Fucus and Gigartina. The animals were Littorina, Mytilus edulis, Balanus cariosus, Balanus glandula, Odonthalia, and some light populations of amphipods. The same community graded further down to the subtidal. Some of the subtidal organisms included Macrocystis, Nereocystis, and Alaria.

SKF-2: Located on the inner portion of Carry Inlet on Afognak Island, this station is a well-developed sand and gravel pocket beach. The back portion of the profile has a small lake, actually a very large washover pond that has been dammed by a heavily vegetated, storm berm. Associated with this berm are logs and wrack. Trees at the top of the storm berm indicate that it may not have been washed over for some 20-50 years. There is very strong evidence of tectonic downwarp on this particular beach. A series of trees to either side of the pocket are all standing dead. Root systems are intact and ace in life position on the upper portion of the beach face indicating tectonic downwarp. The storm berm is about 30 m wide. At the top of the profile is a normal spring high swashline. Moving along the profile, the beach face gradually flattens out and is composed of mostly fine gravel and sand. At the lower portion of the beach face near the water line, the sediment coarsens to fine and medium gravel, fairly well-sorted, and continues offshore.

The general biological setting is one of a rather depauperate beach with a low intertidal Fucus zone which is scattered over Little rocky outcrops. Ecological zones consist of two very sparse communities. One is a wrack debris and terrestrial vegetation zone above an old storm swash line and the other is a Fucus zone. Epifauna in the Fucus zone included Mytilus, Balanus cariosus, Littorina, and amphipods; infauna found were Mya arenaria.

SKF-3: This station faces the open Shelikof Strait. The waves are currently approaching from the northwest and are about 20-30 cm high. However, this area is occasionally subject to very large storm waves. There is a nicely developed, vegetated storm berm covered with a heavy accumulation of spruce logs. Below that are a series of neap berms of sand and gravel, then a small, irregular cuspate berm with sand patches on the middle portion of the beach face. There are about five separate swashlines of fucus. The beach face is quite steep, composed of mostly fine, wel l-rounded gravel and fine to medium sand. There are two large rock headlands on either side of it. Each has large boulders and so forth in front of them and are covered with fucus.

This station has two apparent zones; one being a wrack dominated by decomposing Macrocystis at the storm high-tide swash. Numerous flying insects were associated with the wrack. The second zone is a Fucus Or rockweed zone with increased density to either side of the pocket beach. In the rockweed zone are numerous Balanus cariosus, Mytilus edilus, Odonthalia (all with high densities), and numerous Balanus glandula. Also noted offshore are the presence of scattered Macrocystis-Nereocystis beds.

SKF-4: Located on a small, unnamed island at the head of Red Fox Bay in the Shuyak/Kodiak Strait. This is a bird rookery; nesting sites are on the top of the island in the grassy area. A small soil profile is associated with the grassy zone located on top of bedrock which appears to be highly fractured granodiorite. The profile runs across the zone of exposed rock which is covered with black lichens, and goes across the zone of fucus, then straight down a fairly shear drop to the water. There is little to indicate high wave energy in this area. There are some scattered boulders and so forth on top of it, but it is dominantly a bedrock island. This particular side of the island 1S sheltered. Wave energy is very low and right now, there are no waves at all.

This is a sheltered, rocky-shore habitat with a glaucous-winged gull colony. The two intertidal zones are the *Fucus* or rockweed zone, and the subtidal laminarian zone. These have very abundant *Mytilus*, limpets, *Balanus*, and *Littorina*.

SKF-5: Located near a small stream on Afognak Island, facing the open Shelikof Strait. There is a lot of sand, presumably coming from the stream. Again the indication of downwarp - a lot of dead trees at the top of the beach face in life position. The beach face sediment is about 90-95 percent sand - the rest being a mix of mostly fine to medium gravel. This area is a minor sand and gravel delta with a fairly steep beach face. There is a scarp that is probably 1.5 m high on one side. Wave energy right now is very low (about 30 cm high with a 6-7 second period), but this area is obviously subject to fairly large waves occasionally.

A freshwater stream has its mouth at this point. This is a very low-diversity, low-biomass beach. Few organisms occur except where larger rock outcrops appear which have attached rockweed. Three sea otters were observed in this area.

SKF-6: Facing Foul Bay from Chugach Island, this station is a very narrow pocket beach probably not more than 50-60 m wide, backed by a low rock scarp. The scarp is about 50 percent vegetated with grasses and trees, and is very steep (80-900). Seaward is a gravel rubble pile of angular to subangular, mixed gravel and boulders. One corner of this pocket beach is fine-grained sand. The lower two thirds of the profile is dominated by fine and medium, highly angular gravel on a fine-grained sand matrix. It is about 50 percent gravel and 50 percent sand, and coarsens toward the waterline.

A small pocket beach which consists of coarse material, mainly cobbles, gravel, and sand. The station is at the base of a rock cliff. There appear to be two zonations, both very low in diversity and biomass; the wrack-associated zone and the lower intertidal zone. The wrack zone consists of decaying *Fucus*. Also seen were flies and beetles. The second zone at the water line consisted of *Littorina*, amphipods, Limpets, and *Mytilus* in low numbers.

SKF-7: This station is located on a spit complex adjacent to Ban Island. There is a sand flat in front of it with a low-tide terrace with some algae growing on it. It has a steep sand and gravel beach face with very nicely rounded, medium to coarse gravel on sand. The top portion of the spit is heavily vegetated with grasses and some small trees. There is a large accumulation of spruce logs on the crest of this spit. The exposed side starts at the top of the log accumulation - there is a lot of gravel and one very well-developed berm. The beach is broad and steep, composed of well-sorted gravel, which is very very well-rounded. There are some little sand stringers at the base, an apparent result of an attempt of the beach to Eorm a cuspate berm. The beach has a steep, very high wave energy beach face. The back portion has much lower wave energy, is not as steep, not as well-sorted, not as much gravel. The lower part is pure gravel; the upper half is sand and gravel.

Where there are rocky outcrops, there are *Fucus* areas and green filamentous algae. Beach wrack is lightly scattered. There would he only one zone at the lower intertidal where amphipods or bivalves would be found as burrowing infauna. The green filamentous algae is also on the rocks at the water line and probably constitutes the highest biomass seen on this beach. When we flew in, there were numerous water fowl on this beach.

SKF-8: This profile is located on an exposed section of shoreline facing Paramanof beneath a rapidly eroding mountain side with some large landslides. There is one major slide tongue which projects down to the shoreline and has a Large scarp cut into it. It was first thought to be till because it is mostly clay and sand, but there are a lot of boulders in it too. The deposit is being fragmented and winnowed at the shoreline. There is a boulder accumulation at the base of the landslide. The profile was run adjacent to this accumulation. At the base of the wall, which is partly vegetated and has soil profiles and shear areas here and there, is a very poorly sorted beach face composed of large boulders one and a half to two meters across, mixed with mostly cobbles and small boulders 30-40 cm, and resting on a matrix of coarse-grained sand and gravel. A lot of the larger rocks have quite a number of barnacles On them. The barnacles are located on little suture lines and breaks in the rocks where they can survive impact by gravel being thrown around by the wave energy at high tide. On the lower portion of the beach face, there is one rock type that is completely coated with Mytilus, a mussel, and will appear black in the photographs. They may look like black boulders in the photographs because this area is completely coated with mussels. Wave energy is quite high, 40-50 cm, right now and from the northeast. The beach is a very poorly sorted mixture of boulders and cobbles on sand and gravel, and is obviously perched on a bedrock platform which is buried underneath the veneer and does not outcrop anywhere on the beach face.

This transect extends through a number of zones including a Macrocystis bed offshore. It is a high energy area with freshwater influence from behind and a number of waterfalls. The zonation is spread out; the Balanus zone being wide, and the Fucus zone being rather narrow. The upper zone is comprised of a Balanus cariosus-Mytilus zone and then there is a lower intertidal zone with more of a subtidal association. The Balanus-Mytilus zone is influenced by the presence of freshwater runoff. The Mytilus and B. cariosus are extremely dense. The lower zone consists of Enteromorpha, Laminaria, Alaria, Halasaccion, and other red and brown algae. Generally, it is a mixed Fucus and lamanarian zone. This zone continues out toward the subtidal laminarian zone and then into a Nereocystis bed offshore.

SKF-9: This station is located on Afognak Island and fronts a well-developed till scarp 15-20 m high. There is a broad, steeply sloping, high energy beach face beneath it. The gravel on the upper part of the beach face is well-rounded, mostly boulders with a thick matrix of sand and fine gravel. The lower portion of the beach face at the waterline is all very coarse gravel, cobbles, and boulders - well-rounded and covered with green filamentous algae. Wave energy is quite high, and there is a very nice sorting of beach material. The middle portion of the beach is dominated by much coarser cobbles and boulders. This is one of the few areas where there is till material on the Afognak Island section of our study area. This is a long, broad pocket beach; it is probably about 1.5 km wide. It faces the open Shelikof waves. Evidently the glacier was between the two major peaks behind us, leaving a valley till.

A very exposed, coarse-boulder beach covered with green filamentous algae. There is also some degree of freshwater runoff. Large numbers of Littorina are present. The depauperate nature of the beach is due to the high wave energy at this station. There is one boulder zone which has a band of green filamentous algae on the exposed surface. Littorina occur around the base and in the cracks, which are areas of low kinetic energy.

SKF-10: This station is Located on the inner northern shoreline of Malina Bay; a very sheltered, poorly sorted pocket beach. Again, there is strong indication of tectonic downwarp. Most of this inner portion of the bay has a narrow string of dead trees behind it. The profile is set up on a small spit enclosing a little stream which has evidently supplied quite a bit of fairly fine material and gravel to this area. There is a grassy vegetated hill directly behind the profile; in front of that is a narrow marsh. The marsh grass is about 20 cm high, and almost every stalk has been nipped off at the top by grazing deer. In front of that it slopes down a little more steeply onto a mud flat with superficial gravel and a lot of subsurface gravel; it is quite difficult to dig in and is probably about 30 percent gravel, 30 percent sand, and 30 percent mud. Some of the mud is organic. The marsh is fairly flat. There is a little bit of ponded water behind the marsh, like a lagoon. Its mud floor is similar to a tidal flat section. The spit has a steep slip face, a little berm, and a medium-steep beach face composed of fine to medium, extremely angular gravel on a sand substrate. The water Line is a mixture of sand, mud, and gravel; again very similar to the lagoon. There are indications of very low wave energy here (i.e., extremely poorly developed neap berms, some floatsom, some swashlines, and mud).

SKF-11: Located on a small island in the inner portion of Malina Bay, this station is a bird rookery. There are quite a few nests with eggs in them perched on a bedrock island with a soil veneer and very thick dense grass and alders on it. It is protected and very sheer, clean bedrock that drops almost vertically into the water. Very clear biological zonation is evident on the rocks from the grass surface on the top through terrestrial lichens into a barnacle line, a mussel and fucus zone, and into mostly fucus at the base. There are probably a few more zones subtidally, but it is essentially a typical, protected or sheltered rocky headland. There are approximately 300-400 gulls in the area.

A bald eagle nest with one eagle was noted along the river about 100 m from the beach. A colony of glaucous-winged gulls was located on the cliffs. Approximately 6 to 12 otters were observed.

SKF-12: This station is located on a very exposed section of the coast, open to the waves of Shelikof Strait. There is a small stream that enters here, supplying a fine angular, rock fragment sand. The big feature of this particular area is that the beach is very wide. It has an extremely well-developed, high storm berm that is totally covered by spruce logs. There is a small scarp in front of it about 30-40 cm high down to the normal, high berm which is about 50 cm wide. It is predominantly fine- to coarse-grained sand and mixed Eine to medium gravel. In the middle of the active beach face is a nicely developed sand berm with a series of small gravel neap berms below that. There are some sand stringers where the beach is trying to form a cuspate berm. Scattered here and there are small sand patches. The dominant sediment is sand (90%); the rest is a mix of mostly medium gravel 10-15 cm across and well-rounded.

There are two zones: (1) a terrestrial vegetation zone and (2) a series of burrows (organisms unknown) at about the low-tide terrace. Talitridae amphipods were found at the last high-tide swash. King crabs were noted near shore, indicating that the area has fishery value.

SKF-13: Located on Dolphin Point and the Raspberry Strait, this area is composed of narrow, rocky headlands and very small, gravel pocket beaches. This little pocket beach is mostly fine to medium gravel on a sand matrix, fairly well-sorted because of high wave energy that comes up the strait in the winter. The rock headlands on either side have a thick-zoned vegetation. Depending on wave approach, these pocket beaches sometimes coarsen in the center, toward the sides, or toward one side depending on the predominant transport direction.

An extensive rockweed zone here includes mussel beds and a distinct barnacle zone. The extensive Fucus area appears to be characteristic of Raspberry Strait. A whale of unknown species was observed here. A pair of eagles were nesting in a grassy knoll on a rock point.

SKF-14: Located on an exposed rocky headland on Raspberry Island, this station is a small pocket beach. There are a whole ser ies of pocket beaches and small exposed headLands here. We ran a profile straight down one of the exposed headlands. It is an almost vertical drop to the pocket beach. This station has a small, irregular pocket heath with a well-developed, pure gravel sur face sitting on a matrix of sand and gravel, mostly fine and medium, well-rounded, (of a very diverse rock type) greenstone schists, a lot of intrusive, and a lot of graywacke. The bedrock in the background is green schist.

The sequence of zonation is very well-developed and distinct. Mussel zones were well-developed, but at the base of this cliff, the gravel has scoured away the mussels.

SKF-15: Located on the outer northern side of Kupreanof Strait. This is a classic, wave-cut platform with a boulder/cobhl~ terrace on top of it. It appears to have very high wave energy. Behind the beach is a rock scarp with barnacles on it but not much else. In front of it is a gently sloping, wave-cut platform, and down to the waterline on top 0[the platform is a fairly uniform layer of coarse gravel, cobbles, and boulders. There are a Lot of Mytilus between the larger boulders.

There are scattered, large populations of Mytilus and rockweed. Distinct Mytilus and Balanus zones were observed. Laminarians are not abundant here due to high wave energy and the rather Large-grain cobbles and gravels which are very abrasive during high wave energy periods.

SKF-16: This station is located on Kupreanof peninsula on a wave-cut platform with a heavy veneer of sediment. The back portion of the profile is about a 6-m high scarp into slates, shales, and graywackes. At the base of the scarp is a nicely developed, sand and gravel heath composed mostly of fine gravel and granules with some medium gravel. There are some large boulders about one meter across fallen from the scarp. In places, the bedrock outcrops. The gravel beach occupies the top two-thirds of the profile. Bedrock begins to outcrop more abundantly at the lower portion of the profile, and there is a nicely developed, wave-cut platform with a boulder/cobble terrace on top of it.

A subtidal laminarian zone is present. This exposed rocky platform is diverse. There are at least 20 animal/plant taxa that could be easily distinguished, especially in the lower and middle intertidal zones which are dominated by

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Fucus, Halosaccion, Rhodymenia, and a red moss-like alga. Chthamalus, Balanus cariosus, Littorina, and Mytilus edulis are also abundant.

SKF-17: Located in Viekoda Bay, this station is near a couple of cabins and a tombolo that extends into the bay. It is a broad, 400-750-m wide pocket beach predominantly gravel and granules. A well-developed storm berm of spruce logs is present in front of a fairly uniform, steep sloping, pure gravel beach which extends to the waterline.

This area has low biomass and diversity. A green filamentous algae zone is found on the rocks in the lower intertidal area.

SKF-18: Located at uganik Passage. Mixed sand and gravel beach in a low- to moderate-wave energy area, characterized by a gently sloping profile. The beach is flanked on both sides by exposed, bedrock headlands. There is quite a bit of log debris deposited on the storm berm. The amount of gravel increases towards the low tide terrace.

It has low biomass and diversity. Beach wrack and terrestrial vegetation are dominant, and nothing was found in the infaunal samples.

SKF-19: Located on the southern portion of Terror Bay, this station is in a very low wave energy area, characterized by a poorly sorted, angular gravel beach and small delta complex formed from a couple of small streams. The rock headlands are sheltered and are very low; the scarp portion is only about 3 m high and drops vertically into the water. There is zoned vegetation but it is not as abundant as that found in more exposed areas. This pocket beach is characterized by very coarse, extremely angular boulders and cobbles, which becomes fine in the center of the pocket beach. The larger ones have a coating of barnacles and fucus. The central portion of the pocket beach near the outflow of the small streams has more mobile gravel.

Two primary zones were observed - rockweed and barnacle.

SKF-20: This station is located in Viekoda Bay and is a bedrock platform with some bedrock boulders scattered on the surface. The back portion of the profile starts on a vertical rock wall and cuts into a phyllite zone. The rock wall has a barnacle community on its surface, with mussels in the smaller sutures. At the base of the rock wall is a six meter section of large subangular to subround boulders. Seaward of the boulders is a small, phyllite gravel/sand beach. The bottom half of the profile is strictly on bedrock. The phyllite is flat and makes a large number of small, shallow tide pools. The bedrock is populated by a moderately dense biological community of various algae. The base of the platform drops fairly steeply into the water and continues offshore as bedrock. This area is usually subjected to fairly high wave energy when the winds come out of the west.

This is an exposed, wave-cut platform with a lush covering of biota at the intertidal zone. Balanus glandula, Fucus, Mytilus, and Littorina sitkana are the most abundant with Chthamalus, Balanus cariosus, and Gigartina also present. The subtidal area has laminarians including Alaria and several Pisaster sp. starfish.

SKF-21: Located on the southwestern side of Uganik Island, this station is at a very poorly sorted, boulder/cobble and gravel beach. It is on a bedrock platform, but it has a fairly thick veneer of sediment. The bedrock outcrops over certain portions of the beach, not a great percentage though. Most of it is covered with fairly large boulders and a lot of gravel that is on a foundation of sand. There is a very rich bivalve community in the sand underneath the boulders. The lower portion of the beach face is covered with a thick algal community and then mussel and barnacle communities up higher.

It has a very rich Fucus-Mytilus-Balanus zone on a wide platform with a laminarian zone at the base of the platform.

SKF-22: This station is located on Afognak Island facing Uganik Passage. It is a mixed sand and gravel beach with four primary sorting zones. The upper zone is a fairly clean sand and gravel storm beach with some logs and floatsam. There are some large boulders at the top of the berm thrown Up by severe storms. Just beneath that is a very sharp contact with a perched peat deposit with some kind of pine rooting in it. At the base of the peat zone is a very dense Littorina population. The peat intersects a clean boulder/cobble terrace. Some boulders are over a meter across, but most of them average about 30 cm or so, subround to subangular and very clean. There is a sharp contact where the boulder/cobble terrace meets the lower boulr3er/cobble terrace with a very heavy coating of barnacles and algae. There are a lot of mussels in between the major boulders, and some sandy sediment and small tidal pools. Then there is a change in slope and a more rapid drop to the waterline.

There is heavy colonization of plants and animals, primarily Fucus and Balanus glandula. Also present are limpets, littorines, starfish, and red, green, and brown algae.

SKF-23: Located in the Northeast Arm adjacent to a gravel pocket beach, this station is on the rock headland to the east. This rock is almost vertical and has a beautifully developed biological zonation - a typical barnacle zone at the top. The beach face and the pocket beach are sand and gravel, predominantly fine graywacke gravel at the base to almost pure gravel at the storm berm. The storm berm is vegetated and has many logs.

No organisms were observed on the mixed sand-gravel beach, but the organisms associated with the platform are extensive, including Balanus glandula, Fucus, and numerous tide-pool organisms.

SKF-24: This station is on the inner porton of the Northeast Arm just next to Sally Island. It is locater) on a very small, circular, shaley, slatey island next to Sally Island. The profile is very simple; it has a steeply dipping 70° slate scarp behind it. At the base of the scarp is a beach face which is lying at about a 15° angle. It is a bedrock platform covered with a layer of slate boulders about 30-40 cm across (the bedrock can be seen almost everywhere beneath them) . This is a low wave energy, rocky shoreline.

This station is heavily colonized by Fucus. There are a number of other algae with the Fucus bed. Balanus glandula, B. cariosus, Littorina, Mytilus, and other rocky shore organisms are also present. Underrock fauna consist of amphipods, nemertean worms, holothurians, and hermit crabs.

SKF-25: Located on a spit in the East Arm, this station has a very steep, gravel and sand beach with a number of zones. A very well-developed storm berm is vegetated with a number of spruce logs at the top. The upper beach face is sand and gravel with a series of neap berms, and has some sand and granule stringers on it which extend about halfway to the beach face. The lower portion of the waterline is a gradually coarsening, low-tide beach/cobble terrace, uniformly coarsening from fine gravel at the top to boulders at the waterline. A number of barnacles have been removed [rem the rock surface, indicative of storm activity.

Balanus glandula, which had heen heavily abraded by storms, was the dominant epifauna observed. Scattered Fucus was also present.

SK F-26: This station is located on a semiprotected, gravel beach (very typical of these inner bay portions) in South Arm. There are rock scarps interspersed with small rock headlands that project out into the water. In most cases, the rock scarps are behind the beach face and have steep, poorly sorted, narrow gravel beaches. Fronting the back portion of this profile is a rock scarp about 10 m high, variably vegetated; waves very rarely hit it. There are barnacles on most of the boulders with a very high floatsom swash just 3-4 m in front of the scarp. The upper spring beach face consists of mixed fine-to coarse gravel, angular, platey graywacke. It gets gradually coarser toward the waterline. In general, there is medium, very platey, subangular gravel on the surface at the top half of the beach. A lot of the larger pieces of gravel and cobbles have Fucus attached (individual pieces of Fucus rather than big, thick clumps).

This is a low-biomass, low-diversity beach. Balanus glandula and scattered Fucus are the dominant species of the intertidal zone. Infauna observed were three species of polychaetes and a nemertean species.

SK F-27: Located on the southern shore of Campbell Lagoon, this station has a high and low marsh perched on some kind of peat . In front of the marsh is a broad, sand and mud tidal flat filling in this lagoon. It is a very broad lagoon, extremely shallow; the whole thing is exposed at low tide. It has high and low marsh vegetation at two bands about six meters wide each and a low peat scarp down to the sandy tidal flat.

Fucus, Ulva, and Littorina are present in this rocky shore community in front of a marsh habitat. This is a spawning site for pink salmon which enter the area by freshwater streams.

SKF-28: This station is on an exposed, rock headland near Cape Ugat, facing the open Shelikof Strait. This is an exposed shoreline: obviously, the waves get extremely large. This particular rock 'type looks like a cross between a graywacke and a slate; fairly massive, it has beautifully developed biological zones on it. It has a very narrow beach with a few scattered boulders on a wave-cut platform.

There are two, major intertidal zones. The upper zone consists of Balanus glandula, Endocladia, Porphyra, and Fucus. The lower zone is comprised of Balanus cariosus and Mytilus. There is also a subtidal zone composed mainly of Alaria just offshore.

SKF-29: Located south of Cape Kuliuk. The upper beach face area is composed of mixed sand and gravel with over 80 percent coarse-grained sand, grading into a more pure, coarse-grained sand beach near the waterline. The back of the profile has a large scarp grading into a till and outwash plain.

This shore is heavily covered by Porphyra. There are several good indications of mobile substrate. One is that the rocks are covered with barnacle plates, and the other is the presence of Porphyra. Polychaetes and mysids were found in digs scraped above the waterline. There are indications of razor clams below the low-tide waterline.

SKF-30: This station is located in a sheltered area of Spiridon Bay. The back of the profile (supratidal area) is a bedrock scarp. The base of the scarp has a large accumulation of very angular shale fragments and boulders. The profile then extends over a narrow bedrock, wave cut platform.

A sheltered, rocky shore with an upper intertidal zone of Balanus glandula, Fucus, Littorina, Porphyra, and a red alga (species unknown). The lower intertidal zone is co predominantly of Mytilus edilus, Balanus cariosus, Halosaccion, Odonthalia, Rhodomela, and encrusting coralline algae.

SKF-31: This station is located in a sheltered area of Spiridon Bay. The profile is on a gravel pocket beach perched on a bedrock platform. The back of the profile displays a vegetated berm. Moving seaward across the middle beach face, the sediments are predominantly mixed sand and gravel. This mixed sand and gravel beach thins out onto a bedrock platform. The platform is angled in such a way that many tidal pools are formed.

A bedrock platform covered with Fucus and Balanus glandula. Many of these are removed by high wave activity and scouring. Mytilus, Littorina, and Rhodymenia are also present in high densities. Fucus is attached to the more stable substrates. There are interspersed mobile gravel beaches that have a large number of Balanus glandula.

SKF-32: Mixed sand and gravel beach in Spiridon Bay. Profile begins at exposed, rocky headland (composed of slate and phyllite), and extends seaward over a medium- to coarse-grained sand and gravel beach. The gravels associated with this station are angular and black - orginally from the headland. Also associated with this station is a small fraction of shell material, probably from broken barnacles on the rock scarp and the adjacent headland. Toward the water Line the gravels become-more discoid.

This is an exposed rocky outcrop with a Fucus zone dominated by Balanus glandula and other animals, including Mytilus, Acmaea, and Littorina. Also in this area are Halosaccion and many other algae.

SKF-33: Located in Uyak Bay, the profile begins at a glacial till scarp. At the base of the scarp is a perched beach of sand and gravel. The middle beach face are is predominantly medium to coarse gravel , some sand. The lower beach face is covered with boulders. Occasionally, bedrock extends through the beach.

There are a few attached algae, scars where Balanus glandula have been scraped off, Fucus, and some mussels growing on the outer parts of the rocks.

SKF-34: This station is on the sheltered side of Zachar Island. The exposed bedrock scarp is made of slatey shale. This is an extremely low wave energy environment. The profile begins at the base of an overhung bedrock scarp; in fact, the last high-tide swash line is about 1 m up the scarp. Large, fallen boulders and blocks are at the base of the scarp. The profile runs irregularly to the waterline. The boulders and rocks are angular.

This is a sheltered rocky shore with relatively low biomass. There are large numbers of Balanus glandula and Littorina. The few attached plants are primarily Fucus.

SKF-35: Amoc Bay. The back of the profile has a low vegetated scarp, primarily mixed sand and gravel. A stream enters the beach and deposits some coarse, angular sediment. The substrate is primarily coarse-grained sand throughout the profile. There is a fine granular, washover deposit which is covered by a dense mussel bed. The bed has stabilized much of the beach sediment. The small area of beach seaward of the mussel bed is coarse, angular sand and gravel.

Approximately 200 to 300 burrows per square meter were observed on the surface. The substrate has a scattered coverage of a brown, moss-like algae. Eelgrass is found in shallow tidal pools. The fauna samples collected here had dimensions of 30 x 30 x 15 cm. A very large number of what are probably polychaetes were collected for counting. The whole top of this tidal flat is nothing but worm-casting, surficial pellets.

SKF-36: Tidal flat environment with fine sediments overlying a gravel basement. The basement sediments were probably deposited as a result of glacial outwash or delta front. The flat extends approximately one kilometer to the first drainage channel. The surface is scattered with several large boulders. The sediments are marked with burrows and worm casting. Fucus is present on many of the boulders.

SKF-37: This profile, located at the head of Uyak Bay, is a pure gravel beach with several berms. There appears to be a general grading of sediments toward the waterline, becoming finer.

SKF-38: Located at west end of Harvester Island, a bedrock scarp is at the back of the profile. Perched directly below the scarp is a well-sorted gravel beach which thins seaward and finally disappears at the wave-cut, bedrock platform. The platform is angled so that a great number of tidal pools are present.

SKF-39: This is a pure gravel beach made of slate and shale. The upper beach face is composed of discoid-shaped gravel. There is a large berm of discoid gravel with an enormous quantity of logs and seaweed at its base. Moving seaward across the beach face, the sediment becomes finer toward the waterline. Two meters seaward of the waterline is a white zone of small shell fragments. The beach profile is gently concave up.

SKF-40: Not visited.

SKF-41: This is a sheltered tidal environment located behind two programing gravel spits. The flat was formed upon a storm-generated, flood-tidal delta and is composed of imbricated gravel. The area is biologically rich with large, dense mussel beds. Oil entering the area would remain for an extremely long time; biological damage probably would be severe.

A large Mytilus bed of at least an acre is present in the tidal area. Along the water's edge are large patches of Mytilus and Balanus cariosus. Encrusting coralline algae can be seen in the small tidal pools that remain at low tide. Many limpets are found in this area.

SKF-42: This station is located in Halibut Bay. The upper beach face is backed by a glacial till scarp. At the base of the scarp is a large deposit of logs and seaweed, and a huge wrack deposit. Sediments in this area are coarse-grained sand. In the middle beach face are several small berms; sediments grade to a medium-grained sand. At the low-tide terrace, which is very well-developed, the sand is medium-grained. There are very large groundwater rills.

A tremendous quantity of beach wrack composed of different kelp species is present on the beach face. Only polychaetes were found in the infauna samples. At the upper beach area behind the berm were holes indicating the presence of amphipods and flying insects were observed over the beach wrack. Shore birds were also seen.

SKF-43: South Bumble Bay. There is a 60-m sheer, bedrock scarp backing this profile. At the base of the scarp is a small, mixed sand and gravel deposit. A small wave-cut platform extends seaward. This is a high wave energy environment.

An extremely high productivity area, the rocks break down into three major zones: (1) a Fucus zone at the high-tide line, (2 an Alaria zone, and (3) a Balanus zone. Vegetation cover is 80-100 percent at the Fucus zone, and 70-100 percent at the Alaria zone. Most other major algae species occur: Spongomorpha, Gigartina, Endocladia, Enteromorpha, Halosaccion, Porphyra, Ulva, Rhodymenia, Alaria, Laminaria, and coralline algae. Three species of sea anemones (Anthopleura, Epiactis, and Tealia) are present along with Littorina, Mytilus, and Katharina (a chiton), and limpets. Three barnacle species are present: Balanus glandula, B. cariosus, and Chthamalus dalli. Large patches of Halichondria, a yellow colonial sponge, were present at the lower intertidal zone.

SKF-44: This is beach fronting an outwash till scarp. At the base of the scarp lies a large wrack deposit of logs and seaweed. The beach face is convex and is composed of mixed sand and gravel with the gravel fraction becoming more dominant toward the waterline. The low-tide terrace is primarily gravel.

This is a low energy area biologically - vegetation is sparse, comprised of Gigartina and a few patches of Fucus. Margaritas nucella, Littorina, and limpets are present. This area would have extremely low productivity. Abundant banacle spa t are on the rocks with M. nucella feeding on them. Rhodymenia, Constantinea, Leptasterias, Mopalia, Epiactis (a sea anemone), Tonicella, Henricia, and limpets are also present,

SKF-45: Low Cape area. This is a very broad, boulder/ cobble terrace on a wave-cut platform, fronting an outwash scarp. Boulders scattered over the profile are quite large (50-100 cm) , and mixed sand and gravel are in the middle beach face area.

Barnacles and Littorina are predominant on this wave-cut platform. It appears to be extremely low biologically. A racoon was observed feeding on the rocks.

SKF-46: Located near Cape Alitak. This profile is a perfect example of a pure gravel beach. The profile begins at the terminus of a super storm berm, and extends upward over a well-sorted, discoid gravel, storm berm. The storm berm is littered with logs and other debris. The profile then takes an enormous drop in elevation (an estimated 37-degree dip) and continues seaward. This is an extremely high energy environment, and would probably be rapidly cleaned by wave action.

Biological activity and productivity is considered very low on this gravel beach. On the hack side of the gravel beach is a protected marsh area and tidal flat with a seagrass bed. A salmon stream and a large mussel bed are also present.

SKF-47: Located near Point Providence, this station is a wave-cut platform with vertical rock scarps on either side.

Three zones occur : (1) Littorina and limpets, (2) Ulva-barnacles, and (3) an Alaria zone with many of the other dominant species of algae.

SKF-48: Located near David Island, this profile displays a well-developed spring berm which is composed of coarse gravel and cobbles. Large cobbles characterize the middle beach [ace area and thin out at the bedrock platform on the lower beach face.

Three zones are present. A Balanus-Littorina zone consists OE B. cariosus and Littorina sitkana. The next zone has Enteromorpha, Balanus, and Chthamalus with Fucus and Rhodymenia. The third zone is Alaria with almost 1(30 percent pure plant coverage. Some Laminaria, Halosaccion, Rhodymenia, and other red and brown algae are also present.

SKF-49: This is a small beach associated with a classic tombolo and is a high wave energy area with coarse sand and bioclastic carbonate. Large linear ripples are present on the back side of the berm, probably formed from overwash.

Samples taken appeared to be polychaetes, some mysid crustaceans, and amphipods.

SKF-50: This site is a broad, wave-cut platform. The bedrock is angled upward about 60 degrees, resulting in the formation of many tidal pools. Tbe profile begins at the base of a 20-m sheer scarp. At the base of the scarp is a small, poorly developed sand and gravel beach. This deposit thins out over the platform. Several small boulders and cobbles are scattered on the platform near the waterline.

The biological community includes zones of Balanus-Littorina, Endocladia, and Alaria. A red algae zone occurs along the water' s edge composed of a Rhodymenia community. There is a waterfall causing a greater amount of green algae growth.

SKF-51: Located in Wide Bay. The environment is an exposed, sand and gravel tidal flat. The profile runs from a small meadow into low marsh. At the edge of the marsh, a narrow gravel beach has developed. From this beach, the profile extends over a silty sand tidal flat, a small tidal creek, and ends near the center of a mixed mud and sand flat. The surface of the flat is intensely burrowed.

Biological activity is moderately high with heavy concentrations of Macoma balthica. The profile runs through a high marsh grass zone, then down onto a high gravel beach. Some of the smaller runoff pools contain a green filamentous algae. The lower intertidal zone is a fine-grained sand beach mixed with coarse, angular gravel where numerous Macoma are found.

SKF-52: North of Wide Bay. This site is a broad, mixed sand and gravel beach. The profile begins on a set of vegetated, well-developed beach ridges. At tbe base of the vegetated foredune scarp lies a large accumulation of spruce logs, wrack , and so forth. The upper beach face is composed of mixed sand and gravel which gradually grades into almost pure sand at the waterline. Scattered, fine- and pea-gravel stringers are present at the low title terrace.

High on the beach, biological activity is fairly low.

SKF-53: South of Hartman Island. A large scarp is present with a perched, sand beach at its base. There are some large cobbles, and the beach thins out over the bedrock platform.

SKF-54: Kanatak Lagoon. This is a sheltered tidal flat. The profile begins at a low granite scarp. The granite is fractured in such a way that large plates of granite have accumulated at the base of the scarp. The profile continues into the flat with sediments becoming fine toward the center. The sediments at the end of the profile arc a mixture of fine-grained sand and mud.

.SS -5: Sheltered, boulder beach within a fjord-like bay backed by a steep, tree-covered till slope. Boulders are well-rounded and range up to one meter in diameter. Grain-size distribution fines seaward. The intertidal zone has abundant attached biota, and wave energy is fairly low.

Two were zones were observed. Tbe upper to mid intertidal zones were dominated by Balanus and Littering. Some green filamentous alga was present. The lower intertidal zone was dominated by Fucus and Mytilus. Also present were Littorina, Balanus, Odonthalia, Idotea, and Notoacmea.

SS-6 : Geographic Bay - Sheltered, sandy tidal flat. Steep, erosional scarp with gravel base. Fringed by a' wide tidal flat composed of medium- to coarse-grained sand. Well-developed, green and brown filamentous algal, mat on surface. Common, small boulders with attached biota. Molluscs and infauna are common.

This sheltered tidal flat is highly productive. Several samples contained the clam species, Mya and Siliqua. Also present were nematodes and Abarenicola. On the rocks in the flat were Balanus and Littorina.

P-6: Interior Kinak Bay – Mixed sand and gravel beach at the mouth of a small delta. Beach composed of very angular, coarse-grained sand and gravel; sediment coarsens seaward.

No infauna were observed. On the larger rocks at the water's edge, Balanus, Littorina, and green filamentous algae occurred in low densities. A seal was observed nearby, and salmon were seen spawning upstream from the beach.

P-8: Located in Aunchack Bay. This shoreline is a wide, steep beach composed of mixed coarse-grained sand and fine composed of fine- to medium-rippled sand. The beach is backed by a one-meter vegetated scarp in glacial till and a log swash line.

No infauna or epifauna were observed. On fish (species unknown) was found stranded on the flat. Gulls were seen using the area.

SS-10: Exposed tidal flat backed by a vegetated slope. Slope is composed of fine-grained sand and is probably relict dune. Wide (20-30 m) storm swash at base of slope composed of logs and cobbles. It is fronted by a wind-deflation flat and tidal flat composed of' well-sorted, fine-grained sand with scattered, fine gravel on the surface. The tidal flat is covered with small, flat-topped ripples.

Infaunal samples showed two different polychaete species and one nematode species. Jellyfish were seen at the water's edge, and glaucous-winged gulls were observed feeding nearby.

P-lo: Jute Bay - Exposed, rocky headland with a poorly developed, boulder beach at base. Steep cliff in eroding bedrock with narrow zone of angular to rounded boulders; exposed to high wave energy. Abundant attached epiflora in intertidal zone.

SS-11: Kanatak in Portale Bay. Cuspate, fine-grained sand beach. Fringing, vegetated, cobble slope terminates in a steep erosional scarp. Log storm swash at base. Seaward is a deflation terrace composed of very poorly sorted, flat gravel shingle, fronted by a second storm swash line. Pebble terrace seaward with numerous low berms or ridges. Fringing beach composed of a surface layer (20 cm) of fine-grained sand on mixed sand and gravel; very flat beach profile seaward of cusps.

Beach wrack of algae was at the last high-tide swash line. Insects were observed on the decomposing algae. No infauna were found in the sieved samples at the water's edge.

P-11: Four kilometers [2.5 mi) west of Cape Igvak. Exposed, mixed sand and gravel beach adjacent to a wide cobble terrace. All part of a small spit.

SHELIKOF STRAITS

* = Rapid
\+ = Detailed
$\phi = -\log_2$ (mm)

M_z = Graphic mean grain size (Folk, 1974)
σ_I = Inclusive standard deviation (Folk, 1974)

STATION NUMBER	MAP NUMBER	LATITUDE (North)	LONGITUDE (West)	GROUND SURVEYS	SEDIMENT INFORMATION	BIOLOGICAL SAMPLES
SKF- 1	1	58°38′45″	152°33′ 6″	+	$M_z = 0.35\phi$ $\sigma_I = 0.25\phi$	✓
SKF- 2	1	58°34′18″	152°31′54″	+	$M_z = 0.30\phi$ $\sigma_I = 0.38\phi$	
SKF- 3	1	58°34′15″	152°39′39″	*		
SKF- 4	4	58°28′13″	152°35′30″	+		
SKF- 5	3	58°25′45″	152°46′12″	*		
SKF- 6	3	58°22′ 6″	152°48′18″	+	$M_z = 0.59\phi$ $\sigma_I = 0.42\phi$	
SKF- 7	3	58°20′10″	152°51′00″	*		
SKF- 8	3	58°17′42″	152°59′12″	+		✓
SKF- 9	2	58°16′30″	153° 4′36″	*		✓
SKF-10	7	58° 9′44″	153°52′00″	+		✓
SKF-11	6	58°11′57″	153°00′20″	*		
SKF-12	6	58°10′37″	153°12′47″	+		
SKF-13	6	58° 6′38″	153° 9′30″	*		✓
SKF-14	6	58° 5′58″	153°11′22″	+		✓
SKF-15	6	58° 2′42″	153°18′20″	*		
SKF-16	10	57°59′12″	153°18′ 9″	+		✓
SKF-17	9	57°55′48″	153°20′35″	*		
SKF-18	10	57°52′21″	153°14′55″	+		
SKF- 19	15	57°43′42″	153°12′43″	*		
SKF-20	10	57°54′35″	153° 9′40″	+		✓
SKF-21	9	57°53′51″	153°29′18″	*		
SKF- 22	9	57°49′18″	153°23′ 8″	+		✓
SKF-23	9	57°46′00″	153°26′ 6″	*		✓
SKF-24	14	57°42′57″	153°21′40″	+	$M_z = 0.40\phi$ $\sigma_I = 0.40\phi$	
SKF-25	14	57°44′51″	153°30′00″	*		
SKF-26	14	57°41′23″	153°32′15″	+		✓
SKF-27	9	57°51′35″	153°39′13″	*		

* = Rapid
\+ = Detailed
$\phi = -\log_2$ (mm)

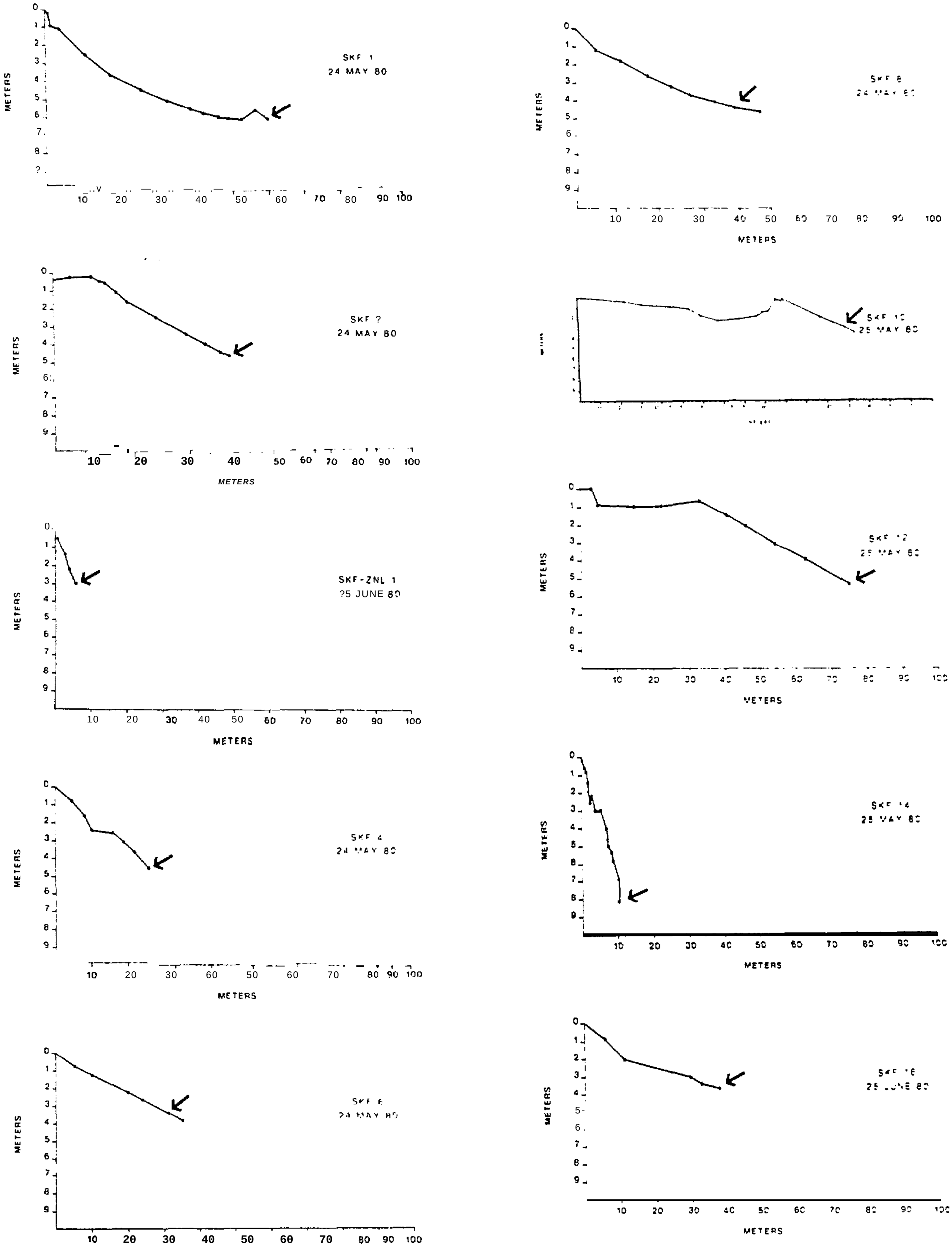
M_z = Graphic mean grain size (Folk, 1974)
σ_I = Inclusive standard deviation (Folk, 1974)

STATION NUMBER	MAP NUMBER	LATITUDE (North)	LONGITUDE (West)	GROUND SURVEYS	SEDIMENT INFORMATION	BIOLOGICAL SAMPLES
SKF-28	8	58°52′00″	153°50′27″	+		✓
SKY-29	8	58°47′22″	153°55′50″	*		
SKF-30	13	57°41′45″	154°49′ 3″	+		✓
SKF-31	14	57°35′27″	154°37′36″	*		
SKF-32	13	57°38′33″	154°42′45″	+		
SKF-33	13	57°35′35″	153°49′15″	*		✓
SKF-34	13	57°34′17″	153°49′45″	+		
SKF-35	18	57°28′50″	153°48′49″	+		
SKF-36	19	57°17′43″	153°39′29″	+		✓
SKF-37	12	57°38′26″	154°17′18″	*		✓
SKF-38	12	57°39′ 7″	154° 2′ 7″	+		✓
SKF-39	13	57°32′ 5″	153°57′ 0″	*		✓
SKF-40	NOT VISITED					
SKF-41	11	57°32′15″	154°31′14″	*		
SKF-42	16	57°25′15″	154°42′38″	+	$M_z = 1.51\phi$ $\sigma_I = 1.07\phi$	
SKY-43	16	57°16′ 7″	154°40′20″	*		
SKF-44	20	57° 6′27″	154°31′12″	*		
SKF-45	21	56°59′45″	154°30′45″	*		✓
SKF-46	22	56°51′ 9″	154°18′ 4″	+		✓
SKF-47	23	56°59′22″	156°33′12″	*		✓
SKF-48	23	57° 3′00″	156°30′39″	+		
SKF-49	23	57° 7′39″	156°24′45″	*		
SKF-50	23	57°12′36″	156°23′ 6″	*	$M_z = 0.16\phi$ $\sigma_I = 0.31\phi$	
SKF-51	24	57°17′15″	156°31′15″	*	$M_z = 2.65\phi$ $\sigma_I = 0.76\phi$	
SKF-52	24	57°24′38″	156°20′41″	*	$M_z = 0.52\phi$ $\sigma_I = 0.57\phi$	✓
SKF-53	25	57°22′12″	156°17′53″	+	$M_z = 1.07\phi$ $\sigma_I = 0.52\phi$	
SKF-54	26	57°31′22″	156° 5′22″	+		

* = Rapid
\+ = Detailed
$\phi = -\log_2$ (mm)

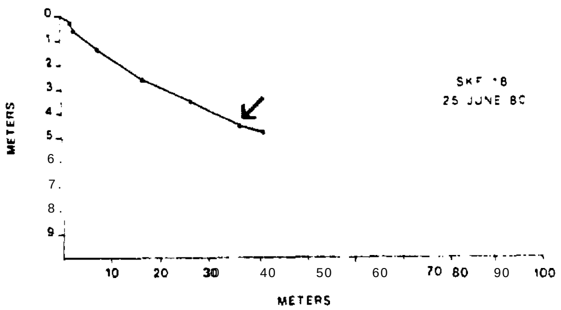
M_z = Graphic mean grain size (Folk, 1974)
σ_I = Inclusive standard deviation (Folk, 1974)

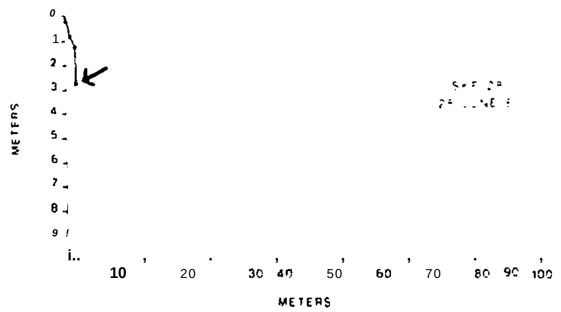
STATION NUMBER	MAP NUMBER	LATITUDE (North)	LONGITUDE (West)	GROUND SURVEYS	SEDIMENT INFORMATION	BIOLOGICAL SAMPLES
SS-5 ˙ "	34	58°10′57″	154°16′12″	+		✓
SS-8	30	57°51′22″	155° 8′55″	+		✓
SS-9	28	57°44′50″	155°27′50″	+		✓
SS-6	33	58° 6′19″	154°31′54″	+		✓
P- 4	36	58°17′ 9″	154°16′45″	*		
P- 6	33	58° 9′32″	154°26′12″	*		
P- 7	32	58°00′27″	154°57′12″	*		
P- 8	28	57°48′10″	155°19′42″	*		
P- 9	28	57°33′22″	155°37′57″	*		
P-lo	27	57°33′22″	155°49′17″	*		
P - n	25	57°26′20″	156°06′15″	*		
ZNL-1	6	58°06′33″	153°05′02″	+		

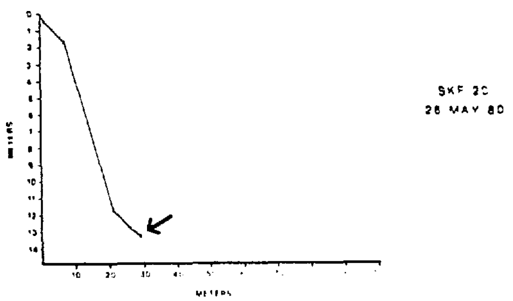


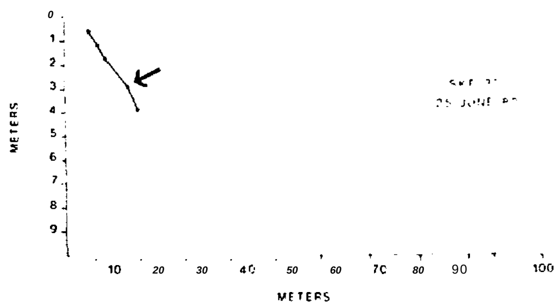
SHELIKOF PROFILES

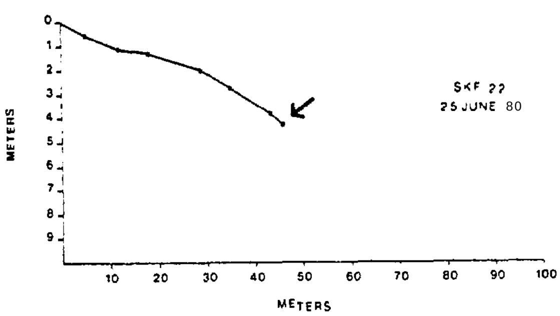
↙ waterline

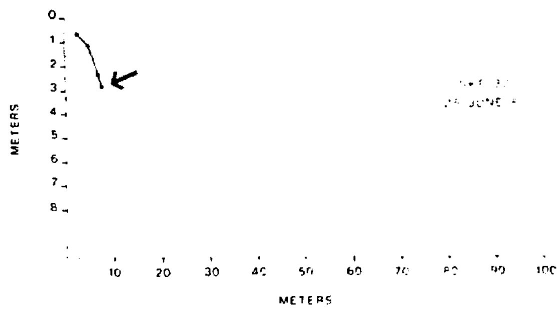


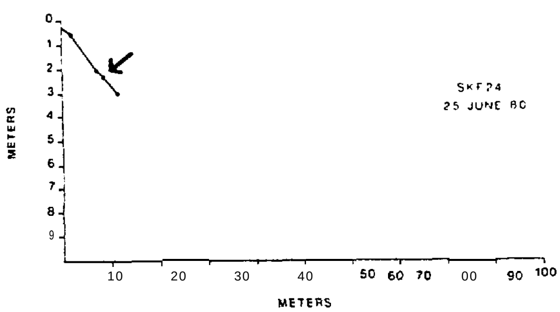


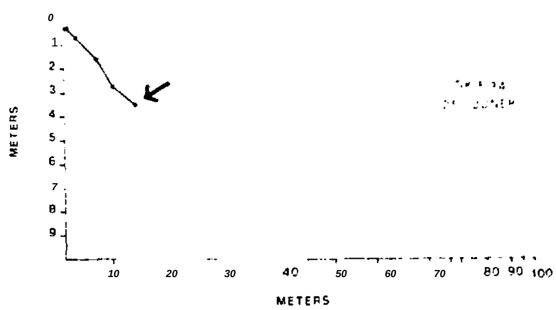


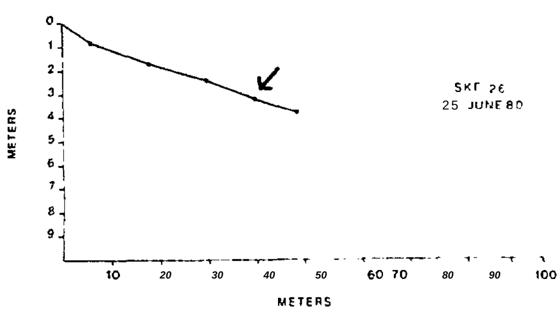


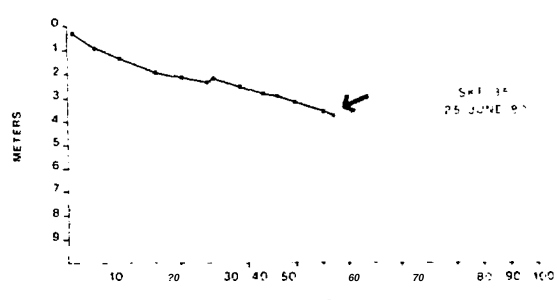






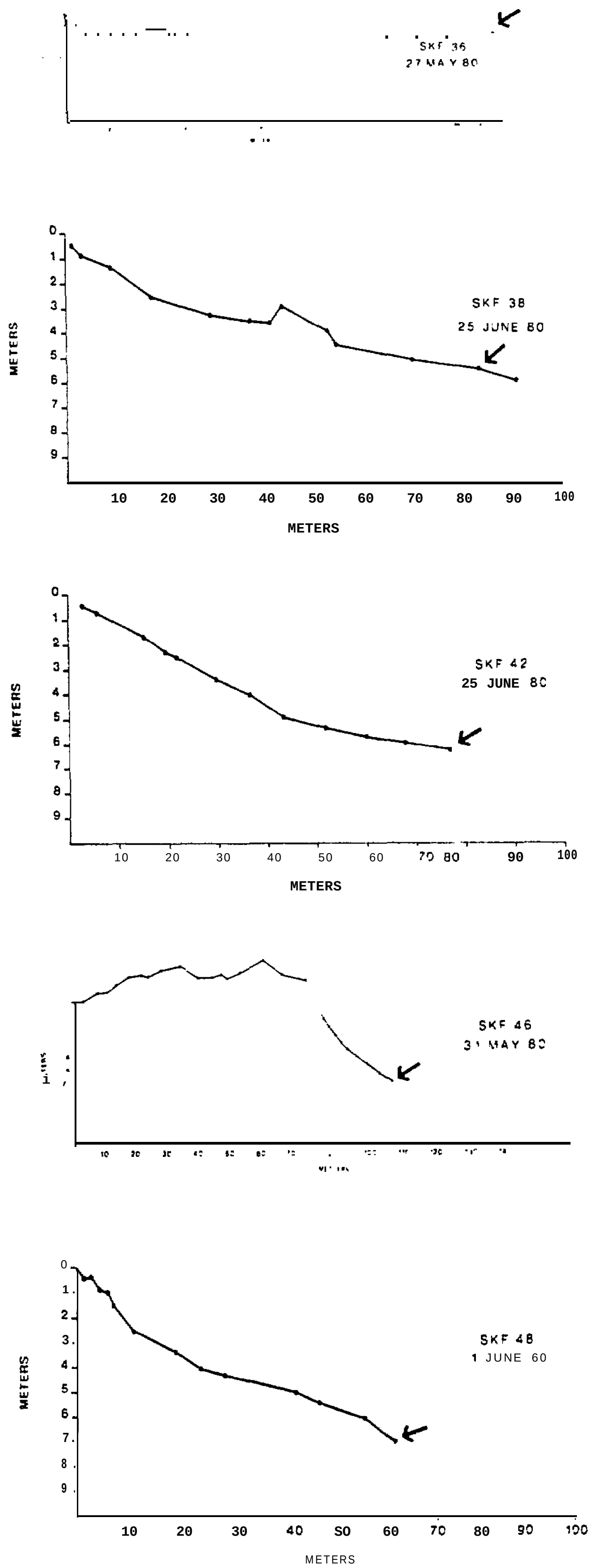




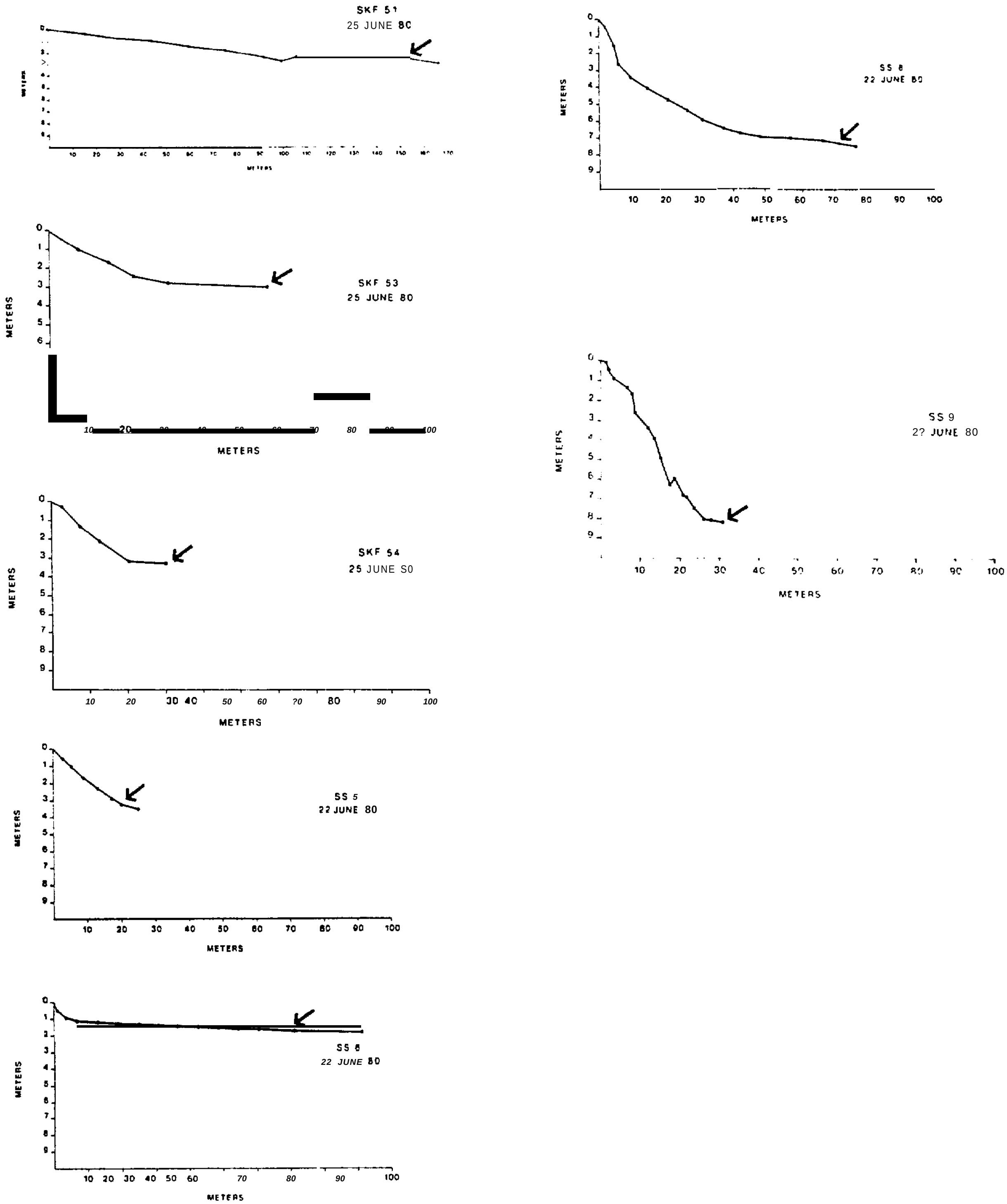


SHELIKOF PROFILES

waterline



SHELIKOF PROFILES ↙ waterline



SHELIKOF PROFILES

↙ waterline

APPENDIX III

SPECIES LIST

Common names and code numbers of the critical species referred to in the text and the map series (revised from Gundlach et al., 1980 and MDEM, 1979).

SHELLFISH

A Shellfish Beds

B Crabbing Area

C Clamming Areas

D Shrimping Areas

E Oyster Farm

SHELLFISH

Ocean Pink Shrimp	*Pandalus borealis*
Northern Pink Shrimp	*Pandalus borealis*
Sidestripe Shrimp	*Pandalopsis dispar*
Spot Shrimp	
Dock Shrimp	
Humpy Shrimp	*Pandalus goniurus*
Coonstripe Shrimp	*Pandalus danae*
Broken-back Shrimp	*Heptacarpus* sp.
Box Crab	*Calappa flammea*
Dungeness Crab	*Cancer magister*
Red Rock Crab	*Pachygrapsus crassipes*
Puget Sound King Crab	*Paralithodes* sp.
Kelp Crab	*Pugettia products*
Pismo Clam	*Tivela stultorum*
Blue Mussel	*Mytilus edulis*
California Mussel	*Mytilus californianus*
Butter Clam	*Saxidomus giganteus*
Common Cockle	*Laevicardium laevigatum*
Horse Clam	*Tresus capax*
Gaper Clam	*Tresus capax*
Soft Shell Clam	*Mya arenaria*

26	Japanese Little Neck	*Venerupis japonica*
27	Piddock	*Penitella penita*
28	Razor Clam	*Siliqua patula*
29	Native Little Neck	*Protothaca staminea*
30	‘octopus	*Octopus dofleini*
31	Northern Abalone	*Haliotis kamtschatkana*
32	Geoduck	*Panopea generosa*
33	Pacific Pink Scallop	*Chlamys hastata*
34	Sea Scallop	*Pecten* sp.
35	Rock Scallop	*Hinnites multirugosus*
36	Hinds’ Scallop	*Chlamys hindsi*
37	Pacific Coast Squid	*Loligo opalescent*
38	Pacific Oyster	*Ostrea lurida*
39	King Crab	*Paralithodes* sp.
40	Tanner Crab	*Chionoecetes* sp.
41	Bay Scallop	*Aequipecten irradians*
42	Quahogs	*Mercenaria mercenaria*
43	American Oyster	*Crassostrea virginica*
44	Horseshoe Crab	*Limulus polyphemus*
45	Lobster	*Homarus americanus*
46	Channeled Whelk	*BusyCon canaliculatum*
47	Knobbed Whelk	*Busycon carica*
48	Surf Clam	*Spisula polynyma*

MAMMALS

1	Northern (Steller) Sea Lion	Eumetopias jubatus
2	Harbor Seal	Phoca vitulina
3	"North Pacific Fur Seal	Callorhinus ursinus
4	Killer Whale	Orcinus orca
5	Pacific Blackfish	Peponocephala electra
6	Pacific Harbor Porpoise	Phocoena phocoena
7	Sea Otter	Enhydra lutris
8	River Otter	Lutra canadensis
9	Beluga Whale	Delphinapterus leucas
10	Manatee	Trichechus manatus
11	Fin Whale	Balaenoptera physalus
12	Minke Whale	Balaenoptera acutorostrata
13	Humpback Whale	Megaptera novaeangliae
14	Gray Seal	Halichoerus grypus
15	Bearded Seal	Erignathus barbatus
16	Walrus	Odobenus rosmarus

REPTILES

1	American Crocodile	Crocodylus acutus
2	Atlantic Green Turtle	Chelonia mydas
3	American Alligator	Alligator mississippiensis
4	Atlantic Ridley	Lepidochelys kempi
5	Atlantic Leatherback Turtle	Dermochelys coriacea
6	Atlantic Loggerhead Turtle	Caretta caretta
7	Diamondback Terrapin	Malaclemys terrapin

FISHES

A Several Species of Salmon

B Forage Fish

FISHES

1	Sablefish (Blackcod)	*Anoplopoma fimbria*
2	Lingcod	*Ophiodon elongatus*
3″	‘Pacific Sanddab	*Citharichthys sordidus*
4	Arrowtooth Flounder	*Atheresthes stomias*
5	Petrale Sole	*Eopsetta jordani*
6	Rex Sole	*Glyptocephalus zachirus*
7	Pacific Halibut	*Hippoglossus stenolepis*
8	Butter Sole	*Isopsetta isolepis*
9	Rock Sole	*Lepidopsetta bilineata*
10	Dover Sole	*Microstomus pacificus*
11	English Sole	*Parophrys vetulus*
12	Starry Flounder	*Platichthys stellatus*
13	C-O Sole	*Pleuronichthys coenosus*
14	Curlfin Sole	*Pleuronichthys decurrens*
15	Sand Sole	*Psettichthys melanostictus*
16	Flathead Sole	*Hippoglossoides elassodon*
17	Slender Sole	*Lyopsetta exilis*
18	Plainfin Midshipman	*Porichthys notatus*
19	Pacific Cod	*Gadus macrocephalus*
20	Pacific Hake	*Merluccius productus*
21	Pacific Tomcod	*Microgadus proximus*
22	Walleye Pollock	*Theragra chalcogramma*
23	Wolf-Eel	*Anarrhichthys ocellatus*
24	Pacific Ocean Perch	*Sebastes alutus*
25	Silvergray Rockfish (Short-Spine)	*Sebastes brevispinis*

26	Copper Rockfish	*Sebastes caurinus*
27	Puget Sound Rockfish	*Sebastes emphaeus*
28	Yellowtail Rockfish	*Sebastes flavidus*
29	Black Rockfish	*Sebastes melanops*
30	Bocaccio	*Sebastes paucispinis*
31	Yelloweye Rockfish	*Sebastes ruberrinus*
32	Canary Rockfish (Orange)	*Sebastes pinniger*
33	Chilipepper	*Sebastes goodei*
34	Redbanded Rockfish (Flag)	*Sebastes babcocki*
35	Rougheye Rockfish	*Sebastes aleutianus*
36	Splitnose Rockfish	*Sebastes diploproa*
37	Greenstriped Rockfish	*Sebastes elongatus*
38	Brown Rockfish	*Sebastes auriculatus*
39	Redstripe Rockfish	*Sebastes proriger*
40	Big Skate	*Raja binoculata*
41	Longnose Skate	*Raja rhina*
42	Ratfish	*Hydrolagus colliei*
43	White Sturgeon	*Acipenser transmontanus*
44	Green Sturgeon	*Acipenser medirostris*
45	Cutthroat Trout (Coastal)	*Salmo clarkii*
46	Kelp Greenling	*Hexagrammos decagrammus*
47	Rock Greenling	*Hexagrammos lagocephalus*
48	Whitespotted Greenling	*Hexagrammos stelleri*
49	Buffalo Sculpin	*Enophrys bison*

50	Red Irish Lord	Hemilepidotus hemilepidotus
51	Pacific Staghorn Sculpin	Leptocottus armatus
52	Tidepool Sculpin	Oligocottus maculosus
53	Cabezon	Scorpaenichthys marmoratus
54	Redtail Surfperch	Amphistichus rhodoterus
55	Kelp Perch	Brachyistius frenatus
56	Shiner Perch	Cymatogaster aggregata
57	Striped Seaperch	Embiotoca lateralis
58	Walleye Seaperch	Hyperprosopon argenteum
59	Pile Perch	Rhacochilus vacca
60	White Seaperch	Phanerodon furcatus
61	Penpoint Gunnel	Apodichthys flavidus
62	Saddleback Gunnel	Pholis ornata
63	Crescent Gunnel	Pholis laeta
64	Quillback Rockfish	Sebastes maliger
65	American Shad	Alosa sapidissima
66	Pacific Herring	Clupea harengus pallasii
67	Northern Anchovy	Engraulis mordax
68	Chinook Salmon (King)	Oncorhynchus tshawytscha
69	Coho Salmon (Silver)	Oncorhynchus kisutch
70	Pink Salmon (Humpy)	Oncorhynchus gorbuscha
71	Cockeye Salmon (Red)	Oncorhynchus nerka
72	Chum Salmon (Dog)	Oncorhynchus keta
73	Masu Salmon (Cherry)	Oncorhynchus sp.

74	Rainbow Trout (Steelhead)	Salmo gairdnerii
75	Surf Smelt	Hypomesus pretiosus
76	Longfin Trout (Steelhead)	Salmo gairdnerii
77	Eulachon	Thaheichthys pacificus
78	Capelin	Mallotus villosus
79	White Seabass	Cynoscion nobilis
80	Pacific Sand Lance	Ammodytes hexapterus
81	Spiny Dogfish	Squalus acanthias
82	Cutthroat Trout	Salmo clarki
83	Salmon Fishery (commerical)	
84	Rainbow Smelt	Osmerus mordax
85	Alewife	Alosa pseudoharengus
86	Blueback Herring	Alosa aestivalis
87	American Shad	Alosa sapidissima
88	Winter Flounder	Pseudopleuronectes americanus
89	Cunner	Tautogolabrus adspersus
90	White Hake	Urophycis tenuis
91	Threespine Sticklebacks	Gasterosteus aculeatus
92	Fourspine Sticklebacks	Apeltes quadracus
93	Striped Killifish	Fundulus notatus
94	Atlantic Silverside	Menidia menidia
95	Mummichog	Fundulus heteroclitus
96	Sanddab	Citharichthys sp.
97	Tautog	Tautoga onitis

98	American Eel	*Anguilla rostrata*
99	Atlantic Tomcod	*Microgadus tomcod*
100	Sea Run Brown Trout	*Salmo trutta*

BIRDS

A Numerous Species of Birds

B Shorebirds

C Waterfowl

D Diving Birds

E Wading Birds

BIRDS

1 Common Loon	*Gavia immer*
2 Arctic Loon	*Gavia arctica*
3 Red-throated Loon	*Gavia stellata*
4 Red-necked Grebe	*Podiceps grisegena*
5 Horned Grebe	*Podiceps auritus*
6 Eared Grebe	*podiceps caspicus*
7 Western Grebe	*Aechmophorus occidentals*
8 Double-crested Cormorant	*Phalacrocorax auritus*
9 Brandt's Cormorant	*Phalacrocorax penicillatus*
10 Pelagic Cormorant	*Phalacrocorax pelagicus*
11 Whistling Swan	*Olor columbianus*
12 Western Canada Goose	*Branta canadensis*
13 Black Brandt	*Branta nigricans*
14 White-fronted Goose	*Anser albifrons*
15 Snow Goose	*Chen hyperborea*
16 Mallard	*Anas platyrhynchos*
17 Pintail	*Anas acuta*
18 Green-winged Teal	*Anas carolinensis*
19 Rock Pigeon	*Columba livia*
20 Northern Shoveler	*Spatula clypeata*
21 Canvasbacks	*Aythya valisineria*
22 Greater Scaup	*Aythya* marila
23 Lesser Scaup	*Aythya affinis*
24 Goldeneye	*Bucephala clangula*
25 Barrow's Goldeneye	*Bucephala islandica*

26	Bufflehead	Bucephala albeola
27	Old Squaw	Clangula hyemalis
28	Harlequin Duck	Histrionics histrionics
29	White-winged Scoter	Melanitta deglandi
30	Surf Scoter	Melanitta perspicillata
31	Common Scoter	Oidemia nigra
32	Common Merganser	Mergus merganser
33	Red-breasted Merganser	Mergus serrator
34	American Coot	Fulica americana
35	Parasitic Jaeger	Stercorarius parasiticus
36	Glaucous-winged Gull	Larus glaucescens
37	Western Gull	Larus occidentals
38	Herring Gull	Larus argentatus
39	California Gull	Larus californicus
40	Ring-billed Gull	Larus delawarensis
41	Mew Gull	Larus canus
42	Bonaparte's Gull	Larus Philadelphia
43	Heermann's Gull	Larus heermanni
44	Thayer's (Herring) Gull	Larus argentatus thayeri
45	Common Tern	Sterna hirundo
46	Common Murre	Uris aalge
47	Pigeon Guillemot	Cepphus columba
48	Marbled Murrelet	Brachyramphus marmoratum
49	Cassin's Auklet	Ptychoramphus aleutica
50	Rhinoceros Auklet	Cercrhinca monocerata
51	Tufted Puffin	Lunda cirrhata

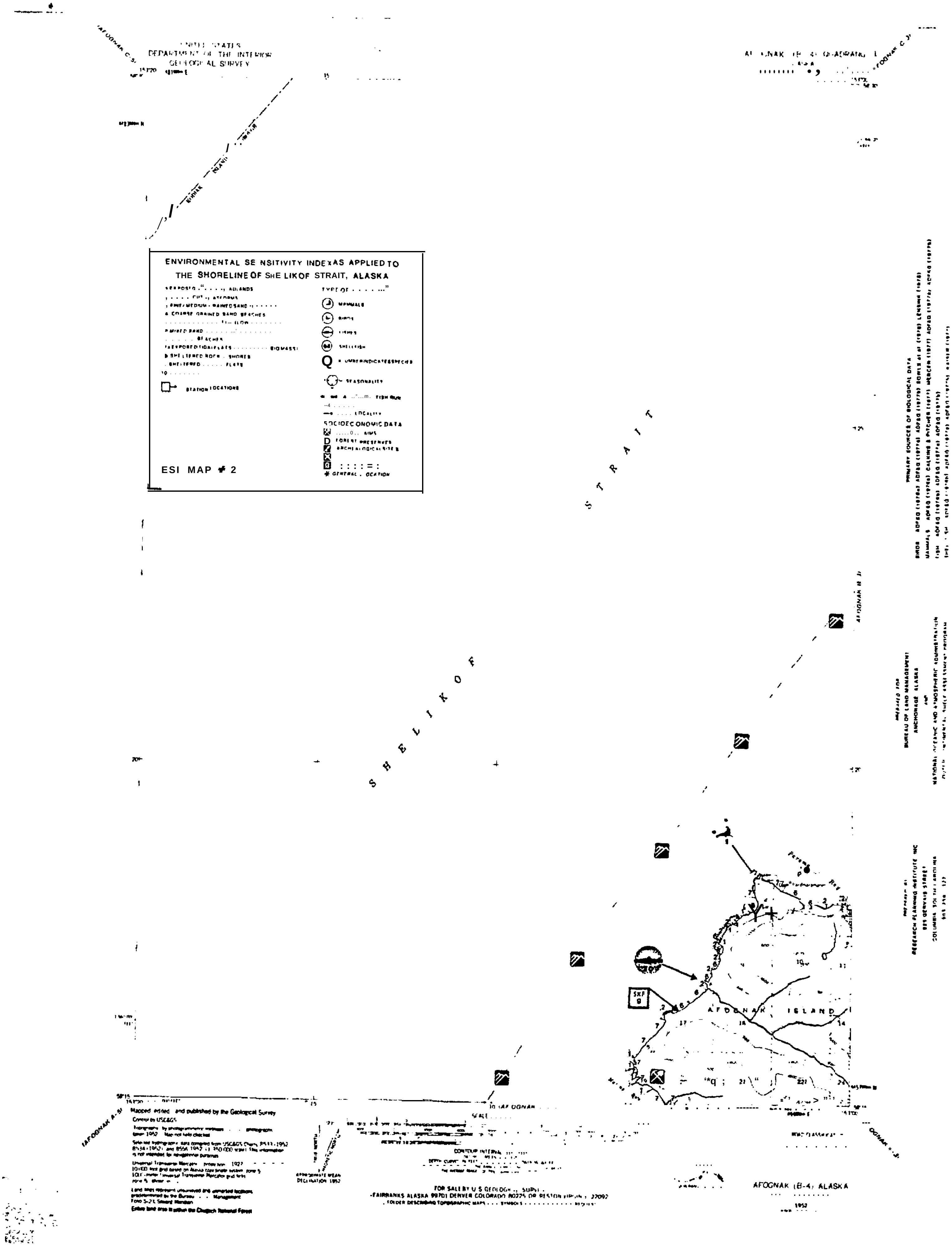
52	Wilson's Phalarope	_Steganopus tricolor_
53	Northern Phalarope	_Lobipes lobatus_
54	Great Blue Heron	_Ardea herodias_
55	Whimbrel	_Numenius phaeopus_
56	Spotted Sandpiper	_Actitis macularia_
57	Wandering Tattler	_Heteroscelus incanum_
58	Greater Yellowlegs	_Totanus melanoleucus_
59	Lesser Yellowlegs	_Totanus flavipes_
60	Red Knot	_Calidris canutus_
61	Pectoral Sandpiper	_Erolia melanotos_
62	Least Sandpiper	_Erolia minutilla_
63	Dunlin	_Erolia alpina_
64	Short-billed Dowitcher	_Limnodromus griseus_
65	Long-billed Dowitcher	_Limnodromus scolopaceus_
66	Western Sandpiper	_Ereunetes mauri_
67	Sanderling	_Crocethia alba_
68	Black Oystercatcher	_Haematopus bachmani_
69	Semi-palmated Plover	_Charadrius semipalmatus_
70	Killdeer	_Charadrius vocirerus_
71	Black-bellied Plover	_Squatarola squatarola_
72	Surfbird	_Aphriza virgata_
73	Ruddy Turnstone	_Arenaria interpres_
74	Black Turnstone	_Arenaria melanocephala_
75	Belted Kingfisher	_Megaceryle alcyon_
76	Northern Bald Eagle	_Haliaeetus leucocephalus_
77	Osprey	_Pandion haliaetus_
78	Northwestern Crow	_Corvus caurinus_

79	Cormorant	*Phalacrocorax* sp.
80	Arctic Tern	*Sterna paradisaea*
81	Horned Puffin	*Fratercula corniculata*
82	Glaucous Gull	*Larus hyperboreus*
83	Kittiwake	*Rissa* sp.
84	Parakeet Auklet	*Cyclorrhynchus psittacula*
85	Pigeon Auklet	*Cepphus columba*
86	Least Tern	*Sterna albifrons*
87	Little Blue Heron	*Florida caerulea*
88	Great Egret	*Casmerodius albus*
89	Snowy Egret	*Leucophoyx thula*
90	Black-crowned Night Heron	*Nycticorax nycticorax*
91	Glossy Ibis	*Plegadis falcinellus*
92	Great Black-jacked Gull	*Larus marinus*
93	Cattle Egret	*Bubulcus ibis*
94	Louisiana Heron	*Hydranassa tricolor*
95	Roseate Tern	*Sterna dougallii*
96	Leach's Petrel	*Oceanodroma leucorhoa*
97	Green Heron	*Butorides virescens*
98	Laughing Gull	*Larus atricilla*
99	Red-faced Cormorant	*Phalacrocorax urile*
100	Black-legged Kittiwake	*Rissa tridactyla*
101	Aleutian Tern	*Sterna aleutica*
102	Fork-tailed Storm Petrel	*Oceanodroma furcata*
103	Common Eider	*Somateria mollissima*

104	Murre	Uris Sp .
105	Thick-billed Murre	Uris lomvia
106	Ancient Murrelet	Synthliboramphus antiquum
107	Peregrine Falcon	Falco peregrinus
108	Kittlitz's Murrelet	Brachyramphus brevirostre
109	Crested Auklet	Aethia cristatella
110	Dovekie	Plautus alle
111	Least Auklet	Aethia pusilla
112	Black Guillemot	Cepphus grylle
113	Gyrfalcon	Falco rusticolus
114	Sabine’s Gull	Xema sabinii
115	White Ibis	Eudocimus albus
116	Roseate Spoonbill	Ajaia ajaja
117	Great White Heron	Ardea occidentals
118	Brown Pelican	Pelecanus occidentals
119	Frigate Bird	Fregata magnificens
120	Yellow-crowned Night Heron	Nyctanassa violacea
121	Anhinga	Anhinga anhinga
122	Scarlet Ibis	Eudocimus ruber
123	Southem Bald Eagle	Haliaeetus leucocephalus

APPENDIX IV

Environmental Sensitivity Maps


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF SHELIKOF STRAIT, ALASKA
MAMMALS
BIRDS
FISHES
SHELLFISH
SEASONALITY
LOCALITY
SOCIOECONOMIC DATA
FOREST PRESERVES
ARCHEOLOGICAL SITES
STATION LOCATIONS
ESI MAP # 2
SHELIKOF STRAIT
AFOGNAK ISLAND
PRIMARY SOURCES OF BIOLOGICAL DATA
PREPARED FOR
BUREAU OF LAND MANAGEMENT
ANCHORAGE, ALASKA
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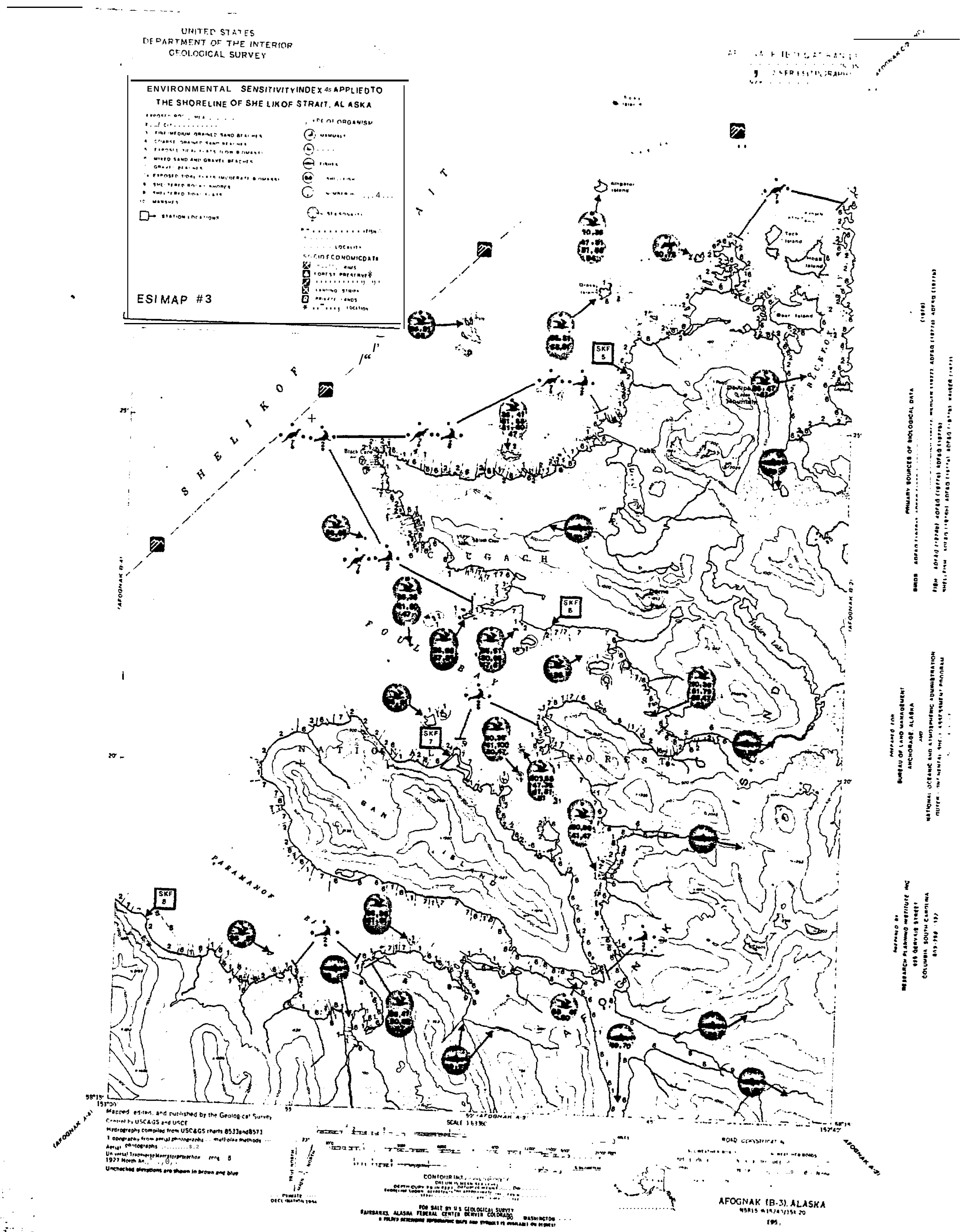
AFOGNAK (B-4), ALASKA
1952


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
ENVIRONMENTAL SENSITIVITY INDEX as APPLIED TO
THE SHORELINE OF SHELIKOF STRAIT, ALASKA
FINE-MEDIUM GRAINED SAND BEACHES
COARSE GRAINED SAND BEACHES
MIXED SAND AND GRAVEL BEACHES
GRAVEL BEACHES
SHELTERED ROCKY SHORES
SHELTERED TIDAL FLATS
MARSHES
STATION LOCATIONS
MAMMALS
FISHES
SHELLFISH
SEASONALITY
LOCALITY
SOCIOECONOMIC DATA
FOREST PRESERVE
LANDING STRIPS
PRIVATE LANDS
ESIMAP #3
SHELIKOF
FOUL BAY
SKF 5
SKF 6
SKF 7
SKF 8
PRIMARY SOURCES OF BIOLOGICAL DATA
PREPARED FOR
BUREAU OF LAND MANAGEMENT
ANCHORAGE, ALASKA
AND
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
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925 GERVAIS STREET
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Hydrography compiled from USC&GS charts 8533 and 8571
Unchecked elevations are shown in brown and blue
SCALE 1:63360
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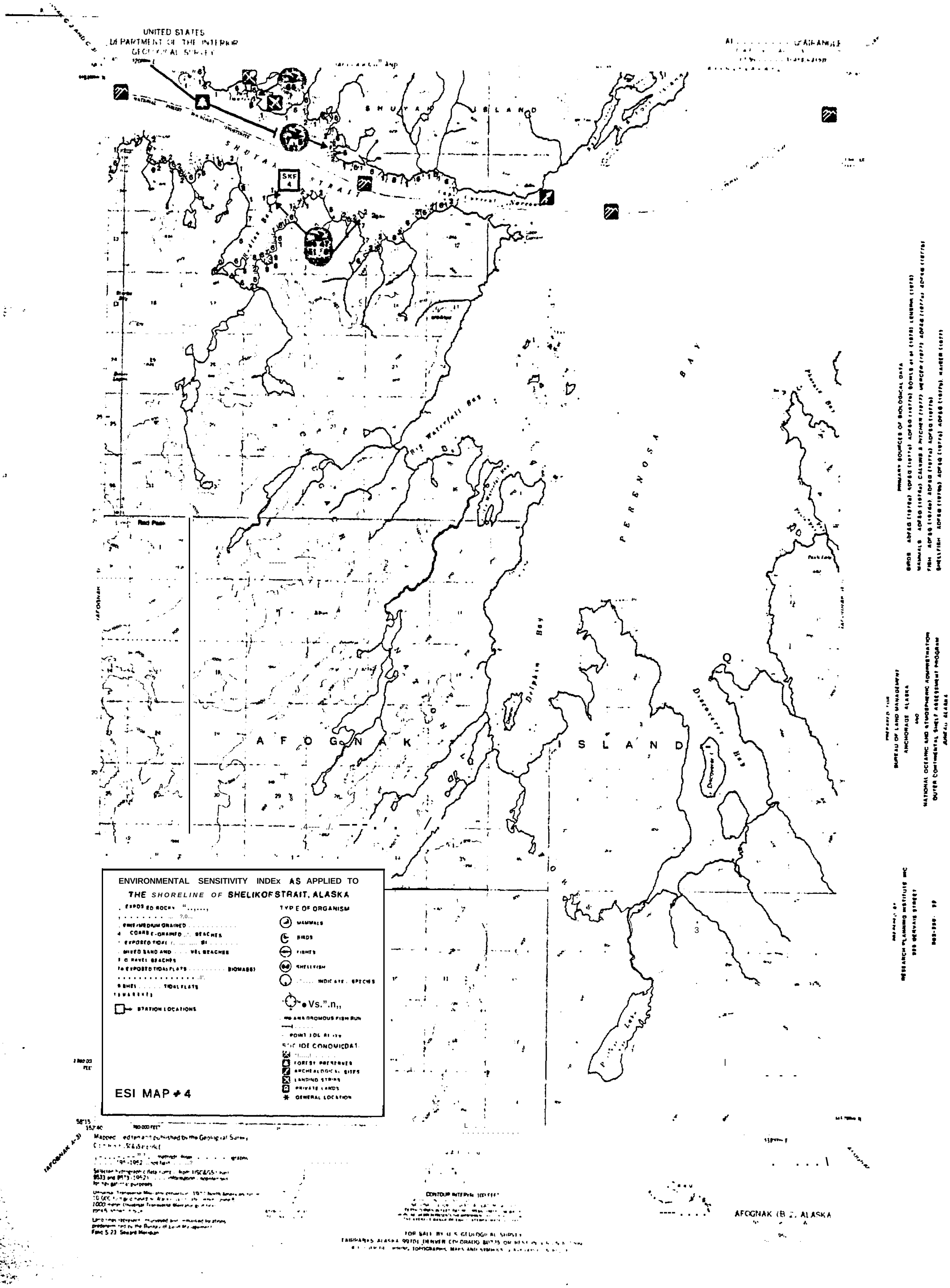
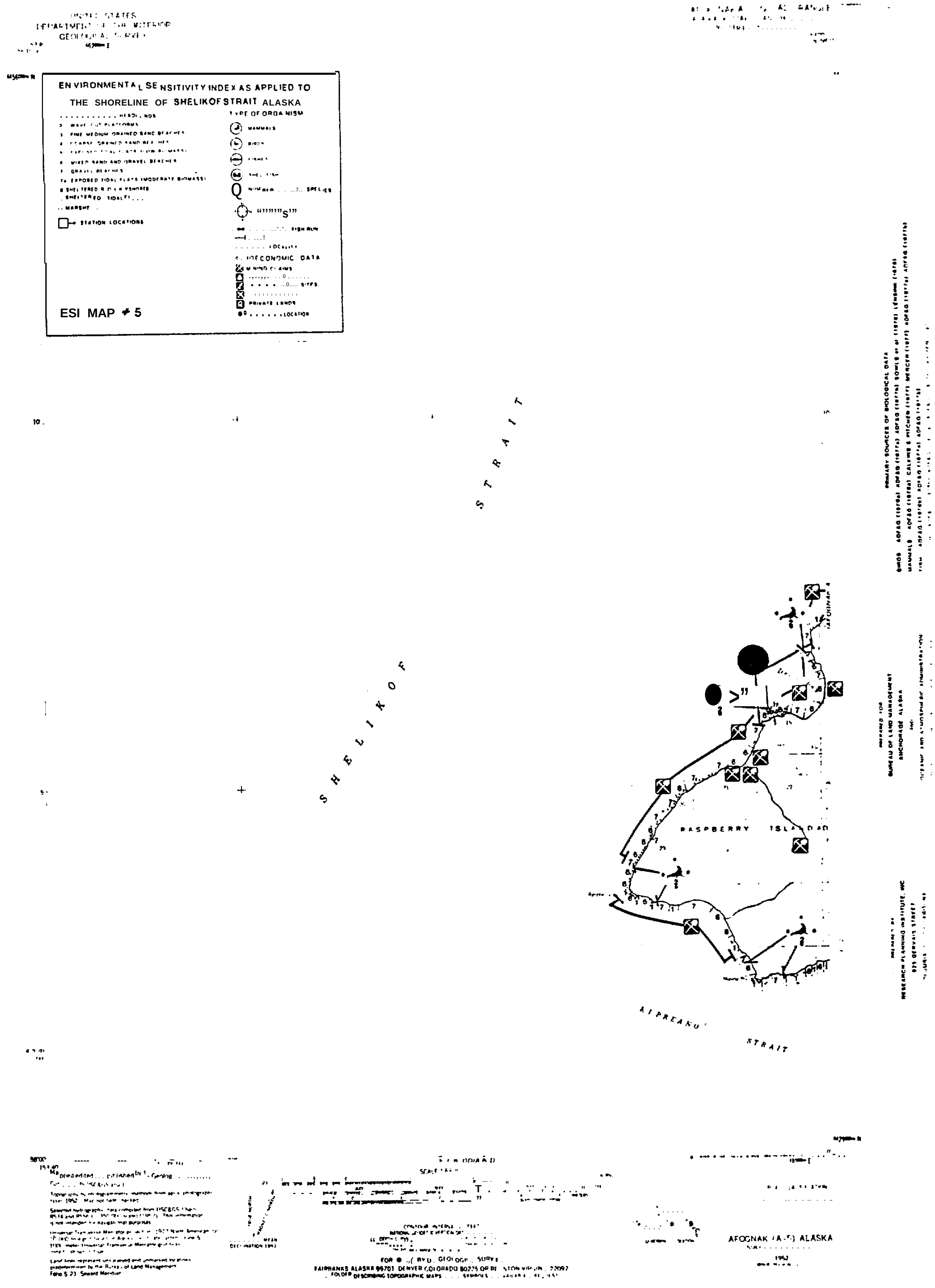
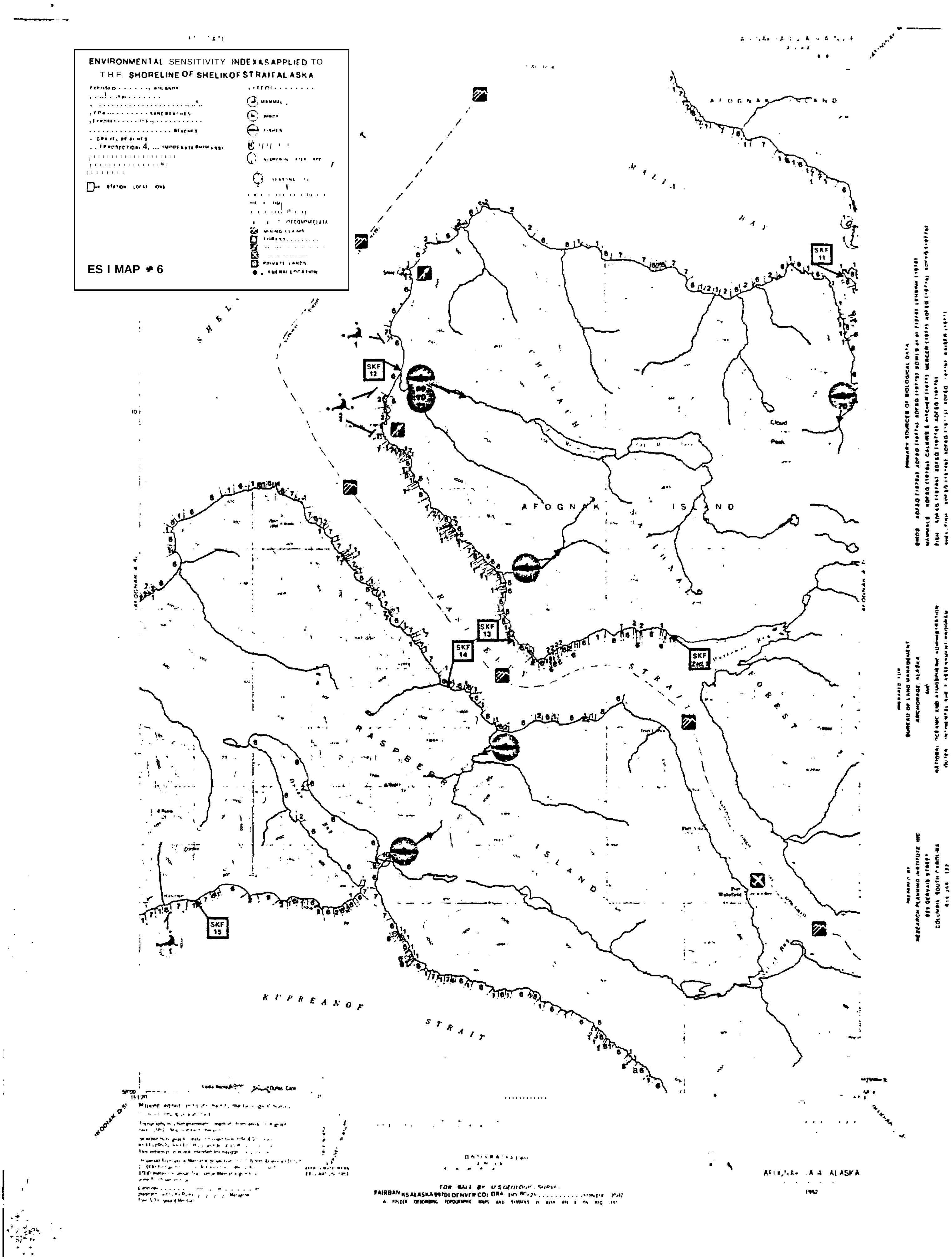
FAIRBANKS, ALASKA
DENVER, COLORADO
WASHINGTON
AFOGNAK (B-3), ALASKA



UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
S H U Y A K I S L A N D
S H U Y A K S T R A I T
SKF 4
Big Waterfall Bay
P E R E N O S A B A Y
Dolphin Bay
Discoverer Bay
A F O G N A K I S L A N D
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF SHELIKOF STRAIT, ALASKA
TYPE OF ORGANISM
MAMMALS
BIRDS
FISHES
SHELLFISH
STATION LOCATIONS
ANADROMOUS FISH RUN
FOREST PRESERVES
ARCHEALOGICAL SITES
LANDING STRIPS
PRIVATE LANDS
GENERAL LOCATION
ESI MAP #4
CONTOUR INTERVAL 100 FEET
AFOGNAK (B-2), ALASKA



ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF SHELIKOF STRAIT ALASKA
TYPE OF ORGANISM
MAMMALS
STATION LOCATIONS
MINING CLAIMS
PRIVATE LANDS
ESI MAP # 5
SHELIKOF STRAIT
RASPBERRY ISLAND
STRAIT
AFOGNAK (A-5) ALASKA
1952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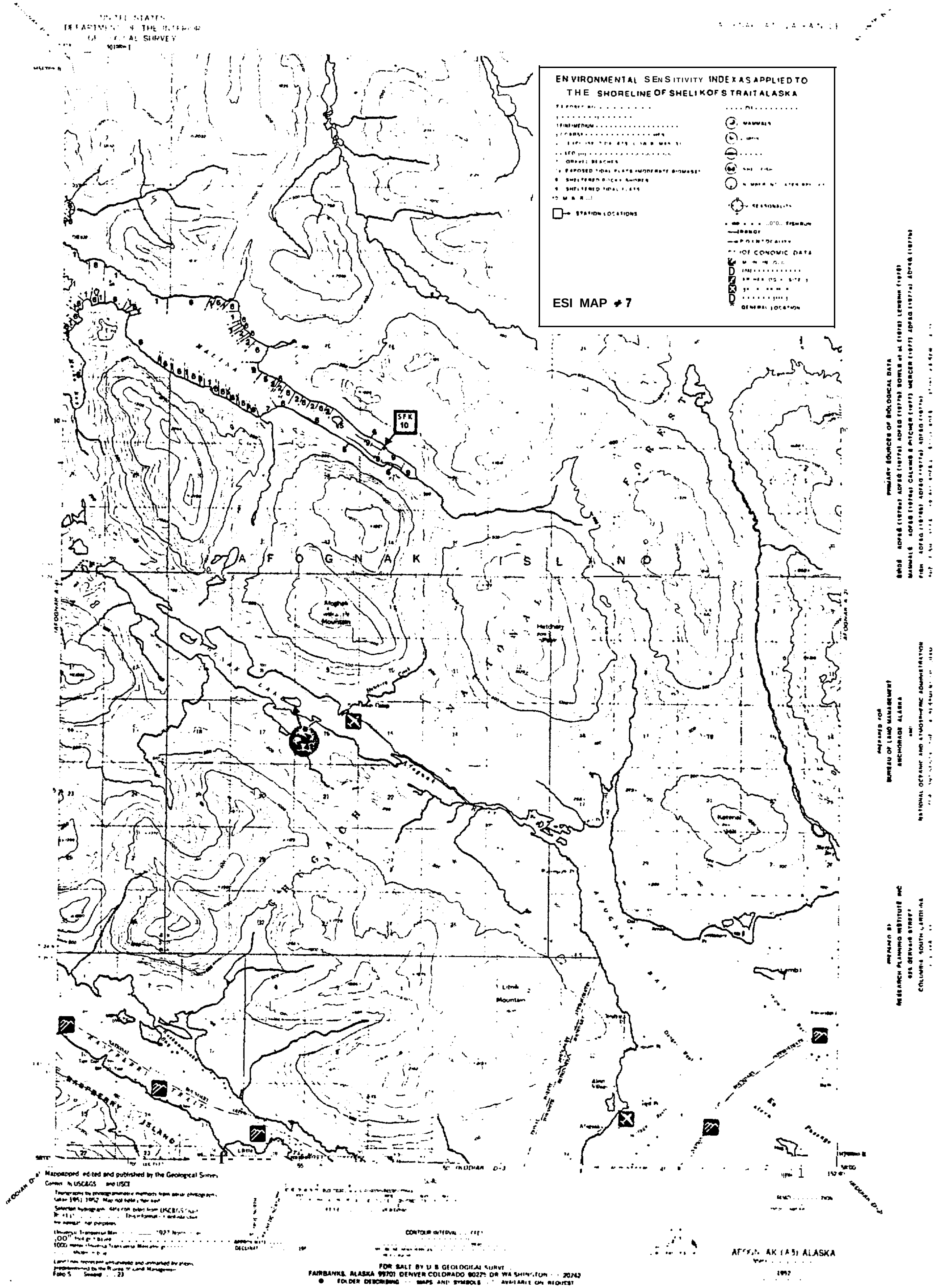
THE SHORELINE OF SHELIKOF STRAIT ALASKA
ES I MAP # 6
STATION LOCATIONS
MAMMALS
BIRDS
FISHES
MINING CLAIMS
PRIVATE LANDS
AFOGNAK ISLAND
MALINA BAY
AFOGNAK ISLAND
RASPBERRY ISLAND
RASPBERRY STRAIT
KUPREANOF STRAIT
SKF 11
SKF 12
SKF 13
SKF 14
SKF 15
Cloud Peak
Port Wakefield
FOR SALE BY U.S. GEOLOGICAL SURVEY
AFOGNAK (A-4), ALASKA



ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF SHELIKOF STRAIT ALASKA
STATION LOCATIONS
ESI MAP # 7
SFK 10
AFOGNAK ISLAND
Afognak Mountain
Little Mountain
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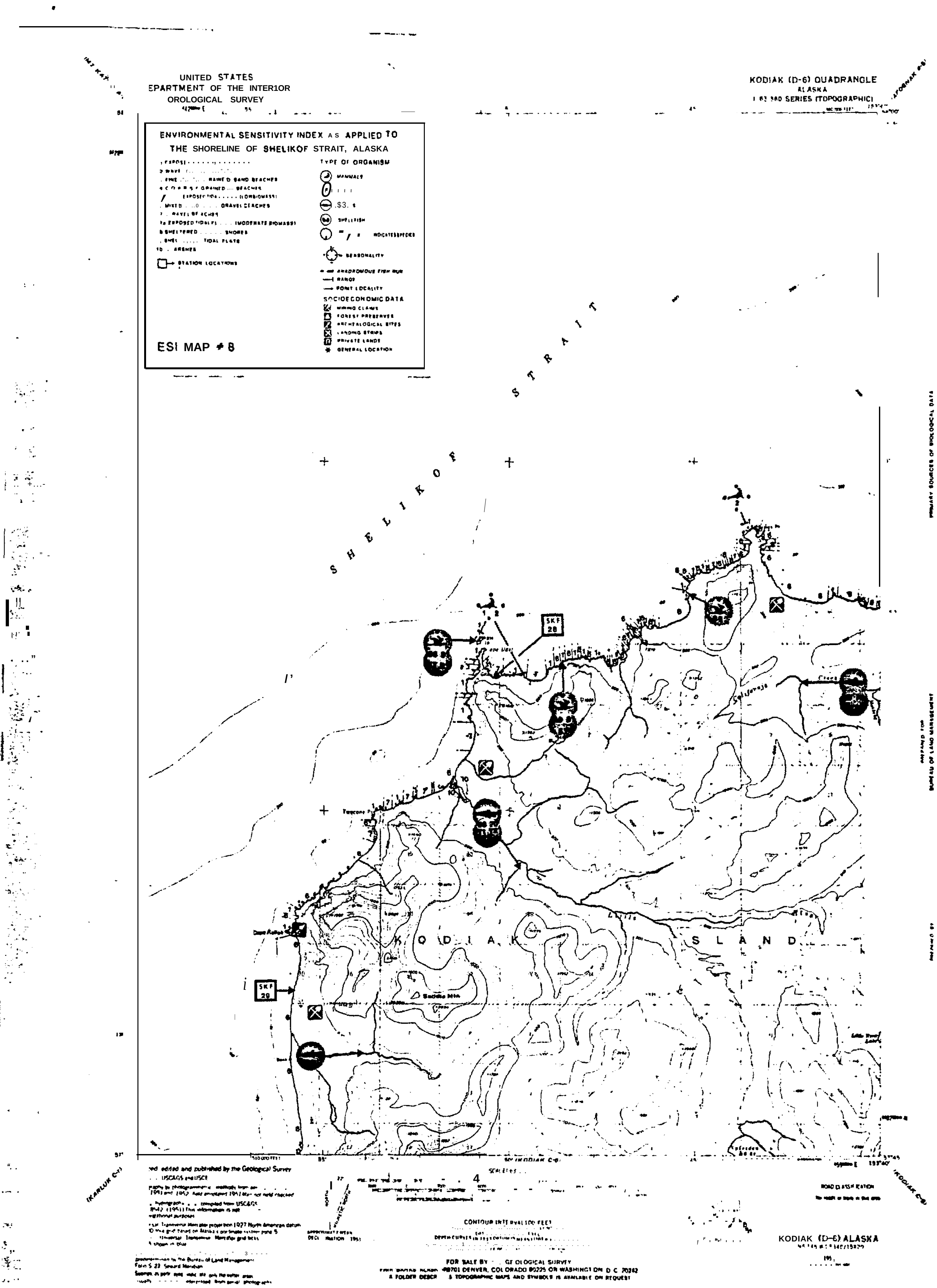
AFOGNAK (A-5) ALASKA
1952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EPARTMENT OF THE INTER1OR
OROLOGICAL SURVEY
KODIAK (D-6) QUADRANGLE
ALASKA
1:63 360 SERIES (TOPOGRAPHIC)
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF SHELIKOF STRAIT, ALASKA
FINE GRAINED SAND BEACHES
COARSE GRAINED BEACHES
EXPOSED TIDAL (LOW BIOMASS)
MIXED GRAVEL BEACHES
EXPOSED TIDAL FLATS (MODERATE BIOMASS)
SHELTERED SHORES
TIDAL FLATS
MARSHES
STATION LOCATIONS
TYPE OF ORGANISM
MAMMALS
SHELLFISH
INDICATES SPECIES
SEASONALITY
ANADROMOUS FISH RUN
RANGE
POINT LOCALITY
SOCIOECONOMIC DATA
MINING CLAIMS
FOREST PRESERVES
ARCHEALOGICAL SITES
LANDING STRIPS
PRIVATE LANDS
GENERAL LOCATION
ESI MAP # 8
SHELIKOF STRAIT
SKF 28
SKF 29
KODIAK ISLAND
Saddle Mtn
CONTOUR INTERVAL 100 FEET
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A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST
KODIAK (D-6) ALASKA
ROAD CLASSIFICATION
PRIMARY SOURCES OF BIOLOGICAL DATA
PREPARED FOR
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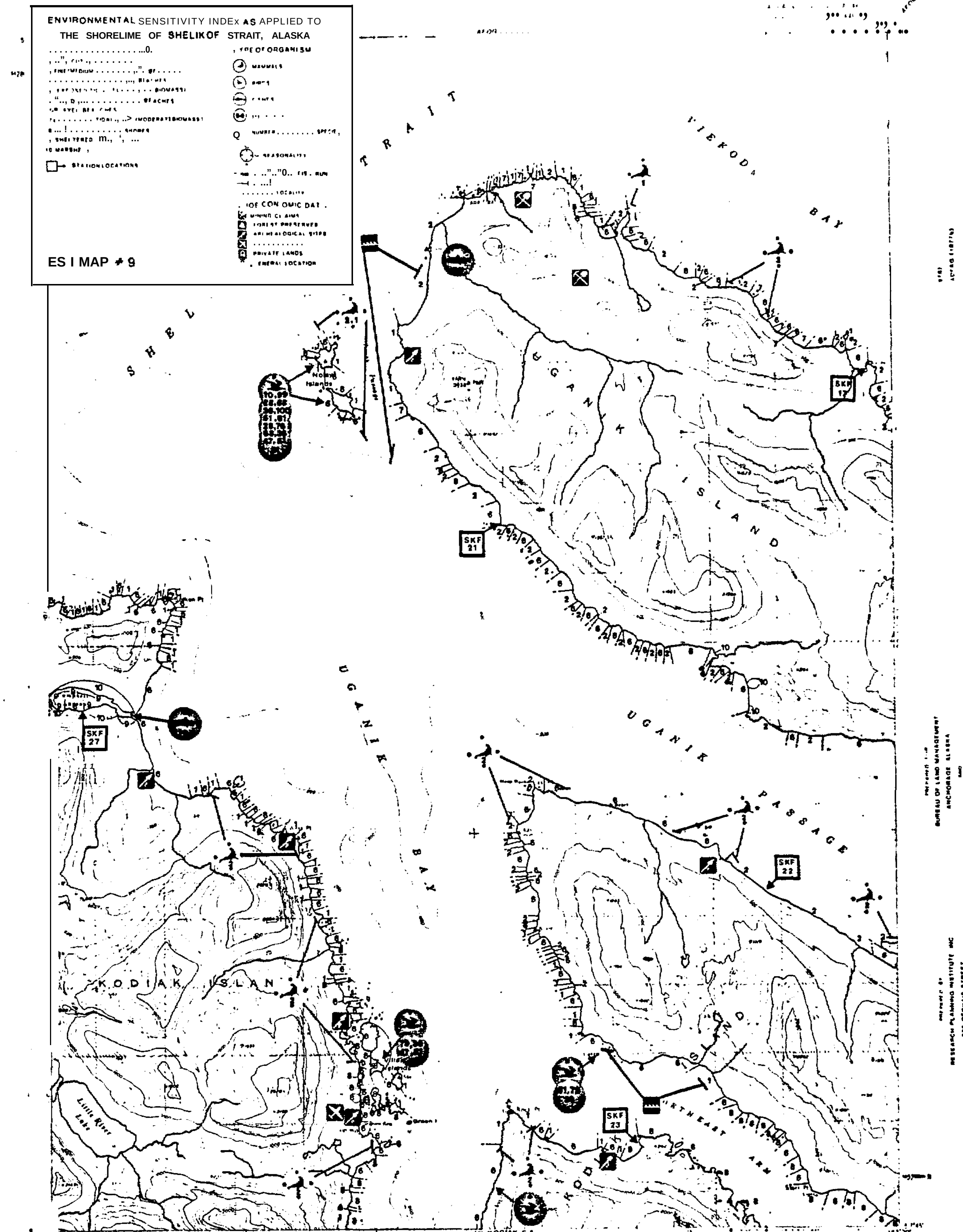
ANCHORAGE, ALASKA
AND
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
PREPARED BY
RESEARCH PLANNING INSTITUTE INC
COLUMBIA, SOUTH CAROLINA
(KARLUK C-1)
(KODIAK C-6)



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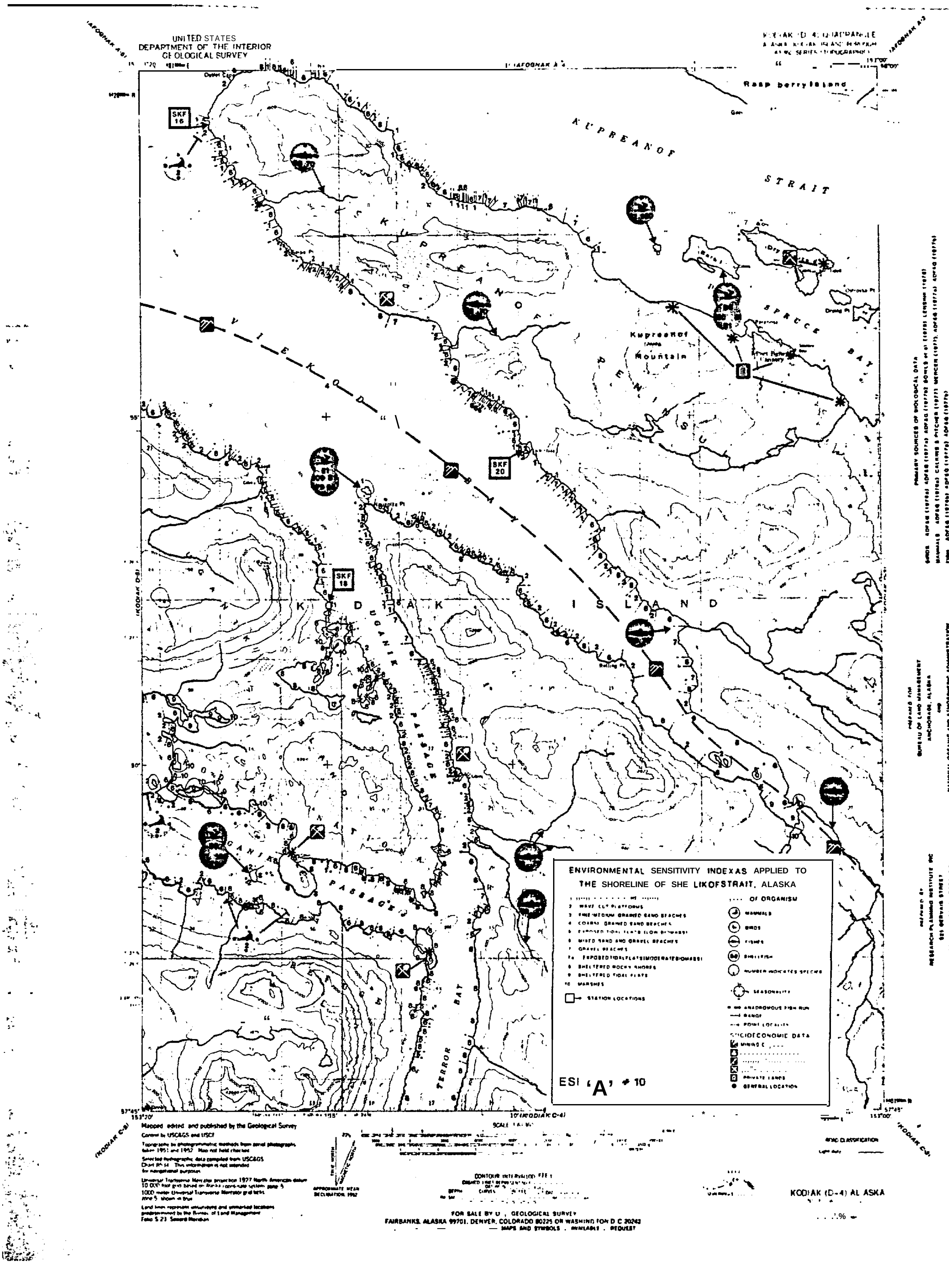

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Raspberry Island
KUPREANOF STRAIT
SPRUCE BAY
Kupreanof Mountain
VIEKODA BAY
KODIAK ISLAND
UGANIK PASSAGE
TERROR BAY
SKF 16
SKF 20
SKF 18
ENVIRONMENTAL SENSITIVITY INDEXAS APPLIED TO
THE SHORELINE OF SHE LIKOFSTRAIT, ALASKA
2 WAVE CUT PLATFORMS
3 FINE/MEDIUM GRAINED SAND BEACHES
4 COARSE GRAINED SAND BEACHES
6 MIXED SAND AND GRAVEL BEACHES
7 GRAVEL BEACHES
8 SHELTERED ROCKY SHORES
9 SHELTERED TIDAL FLATS
10 MARSHES
STATION LOCATIONS
OF ORGANISM
MAMMALS
BIRDS
FISHES
SHELLFISH
NUMBER INDICATES SPECIES
SEASONALITY
ANADROMOUS FISH RUN
RANGE
POINT LOCALITY
SOCIOECONOMIC DATA
PRIVATE LANDS
GENERAL LOCATION
ESI 'A' # 10
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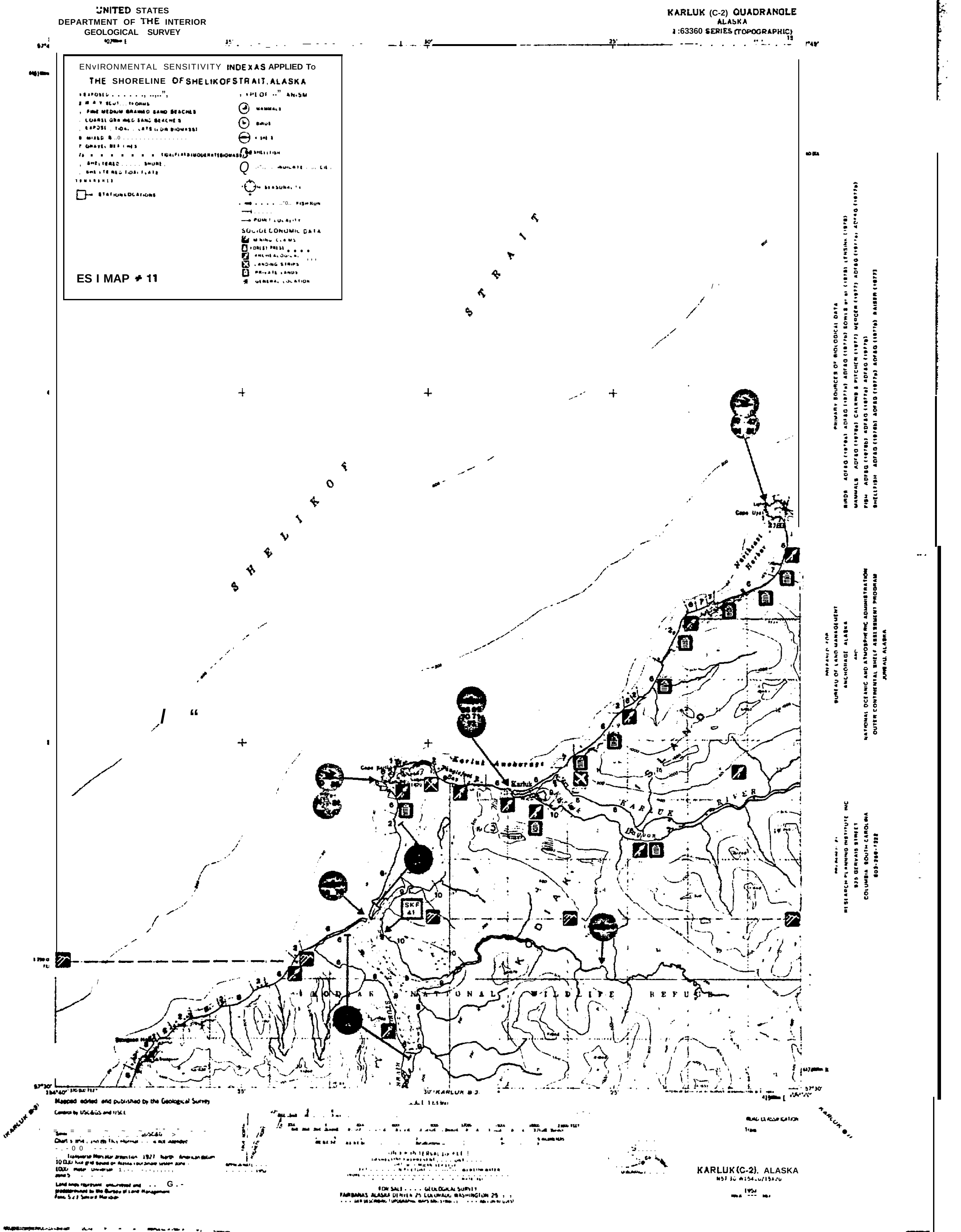
KODIAK (D-4) ALASKA


UNITED STATES
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GEOLOGICAL SURVEY
KARLUK (C-2) QUADRANGLE
ALASKA
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ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF SHELIKOF STRAIT, ALASKA
MAMMALS
BIRDS
SHELLFISH
SEASONALITY
FISH RUN
POINT LOCALITY
SOCIOECONOMIC DATA
MINING CLAIMS
ARCHEALOGICAL
LANDING STRIPS
PRIVATE LANDS
GENERAL LOCATION
STATION LOCATIONS
ES I MAP # 11
SHELIKOF STRAIT
Cape Uyak
Karluk Anchorage
Karluk
KARLUK RIVER
KODIAK NATIONAL WILDLIFE REFUGE
SKF 41
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KARLUK (C-2), ALASKA
1954
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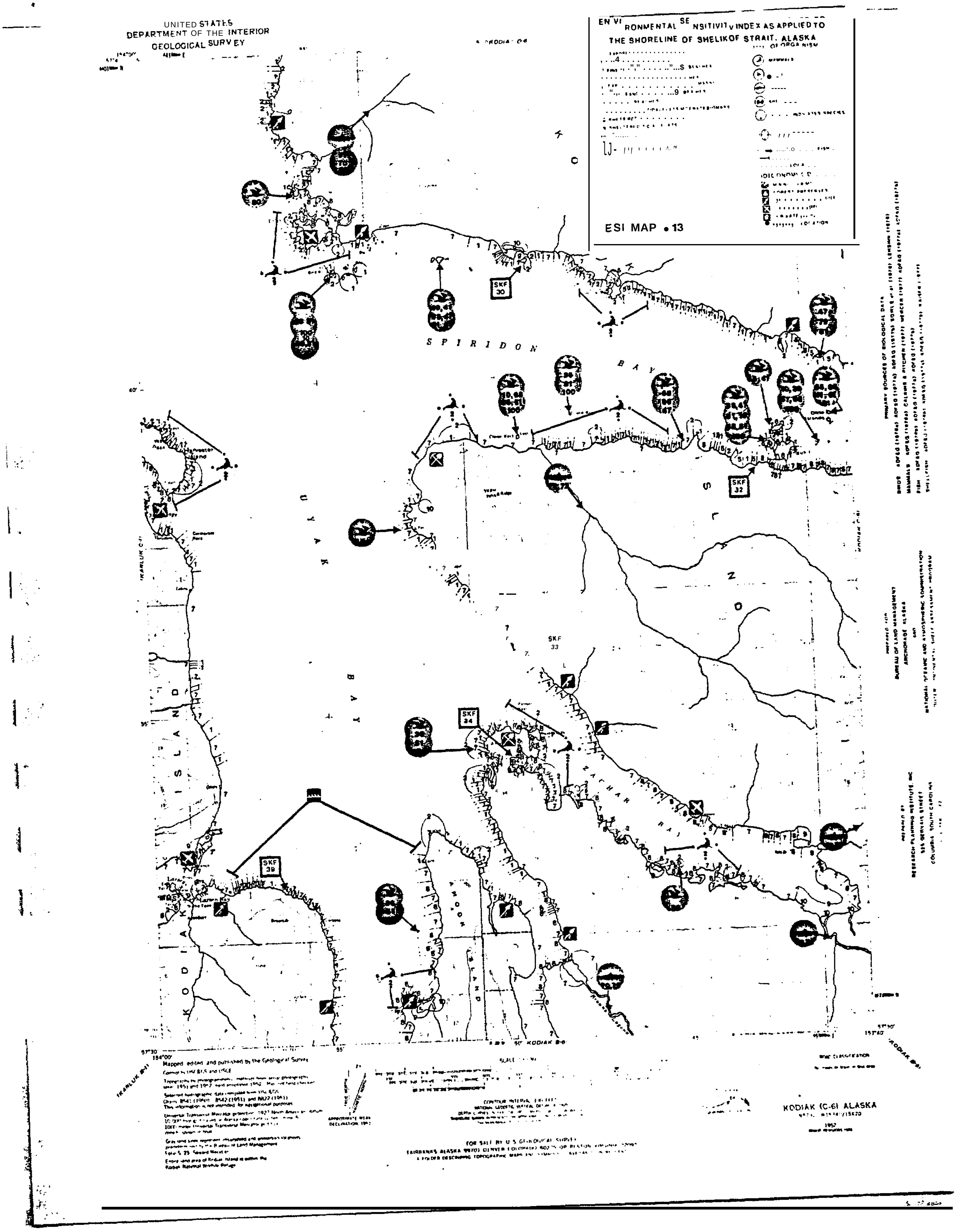

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ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF SHELIKOF STRAIT, ALASKA
ESI MAP • 13
SPIRIDON BAY
UYAK BAY
ZACHAR BAY
KODIAK ISLAND
SKF 30
SKF 32
SKF 33
SKF 34
SKF 39
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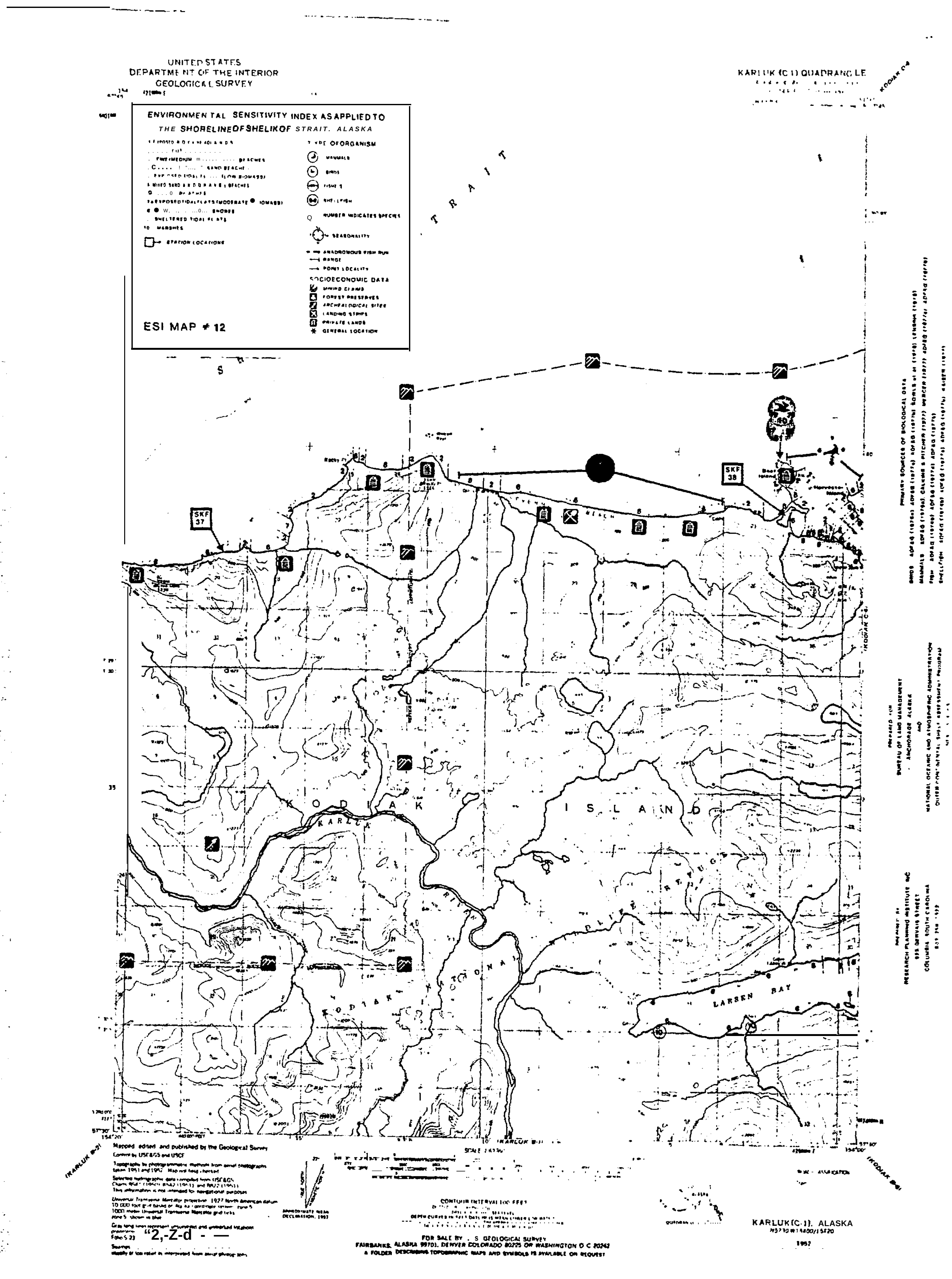
KODIAK (C-6) ALASKA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KARLUK (C-1) QUADRANGLE
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF SHELIKOF STRAIT, ALASKA
TYPE OF ORGANISM
MAMMALS
BIRDS
FISHES
SHELLFISH
NUMBER INDICATES SPECIES
SEASONALITY
ANADROMOUS FISH RUN
RANGE
POINT LOCALITY
SOCIOECONOMIC DATA
MINING CLAIMS
FOREST PRESERVES
ARCHEOLOGICAL SITES
LANDING STRIPS
PRIVATE LANDS
GENERAL LOCATION
STATION LOCATIONS
MARSHES
SHELTERED TIDAL FLATS
ESI MAP # 12
STRAIT
SKF 37
SKF 38
KODIAK
ISLAND
KARLUK
RIVER
LARSEN BAY
KODIAK NATIONAL
WILDLIFE REFUGE
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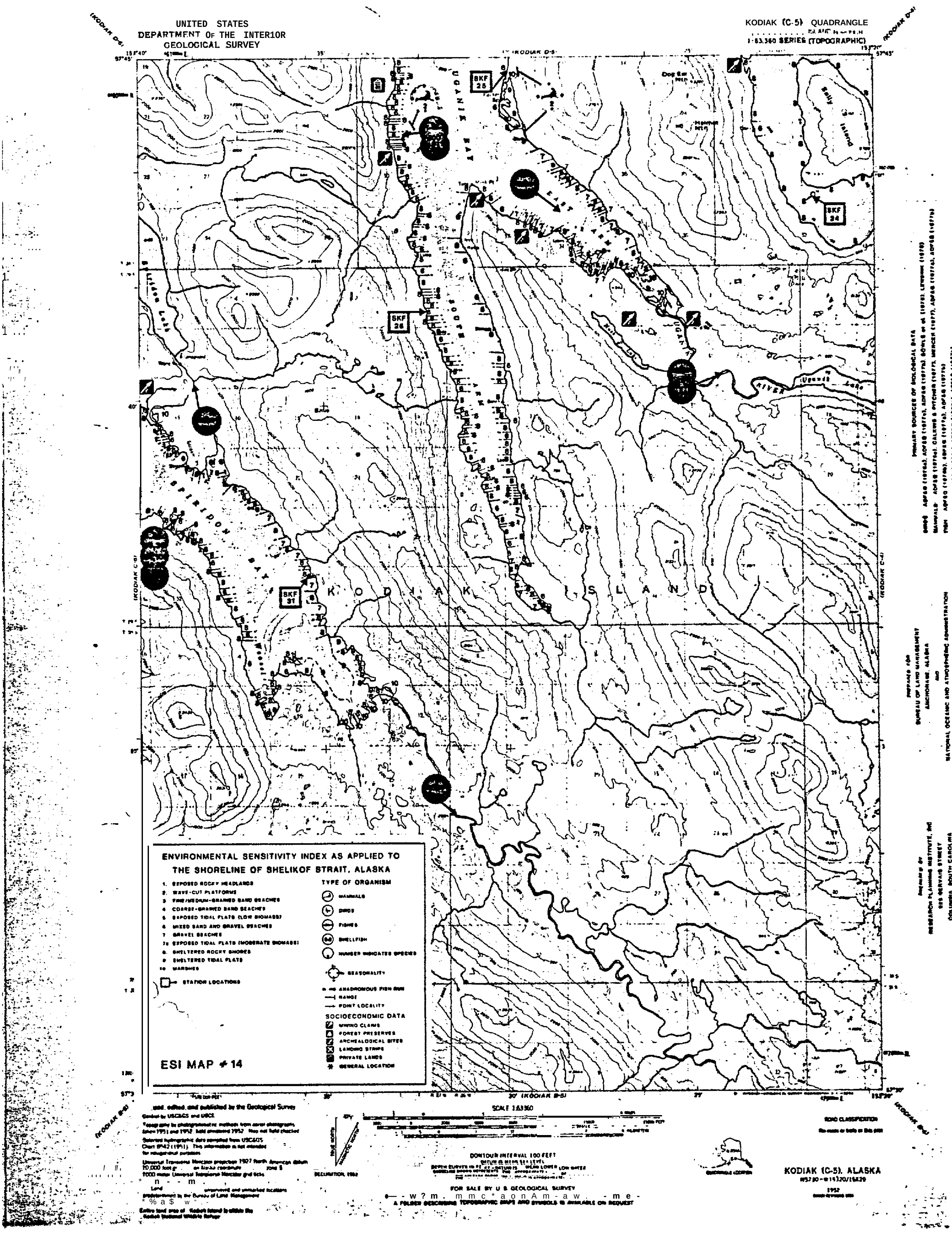
1952
KARLUK (B-2)
KARLUK (B-1)
KODIAK (B-6)
KODIAK (C-6)
KODIAK (D-6)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UGANIK BAY
SOUTH ARM
EAST ARM
SPIRIDON BAY
KODIAK ISLAND
Sally Island
BKF 25
BKF 24
BKF 26
BKF 31
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF SHELIKOF STRAIT, ALASKA
1. EXPOSED ROCKY HEADLANDS
2. WAVE-CUT PLATFORMS
3 FINE/MEDIUM-GRAINED SAND BEACHES
4 COARSE-GRAINED SAND BEACHES
5 EXPOSED TIDAL FLATS (LOW BIOMASS)
6 MIXED SAND AND GRAVEL BEACHES
7 GRAVEL BEACHES
7a EXPOSED TIDAL FLATS (MODERATE BIOMASS)
8. SHELTERED ROCKY SHORES
9 SHELTERED TIDAL FLATS
10 MARSHES
STATION LOCATIONS
TYPE OF ORGANISM
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BIRDS
FISHES
SHELLFISH
NUMBER INDICATES SPECIES
SEASONALITY
ANADROMOUS FISH RUN
RANGE
POINT LOCALITY
SOCIOECONOMIC DATA
MINING CLAIMS
FOREST PRESERVES
ARCHEALOGICAL SITES
LANDING STRIPS
PRIVATE LANDS
GENERAL LOCATION
ESI MAP # 14
SCALE 1:63360
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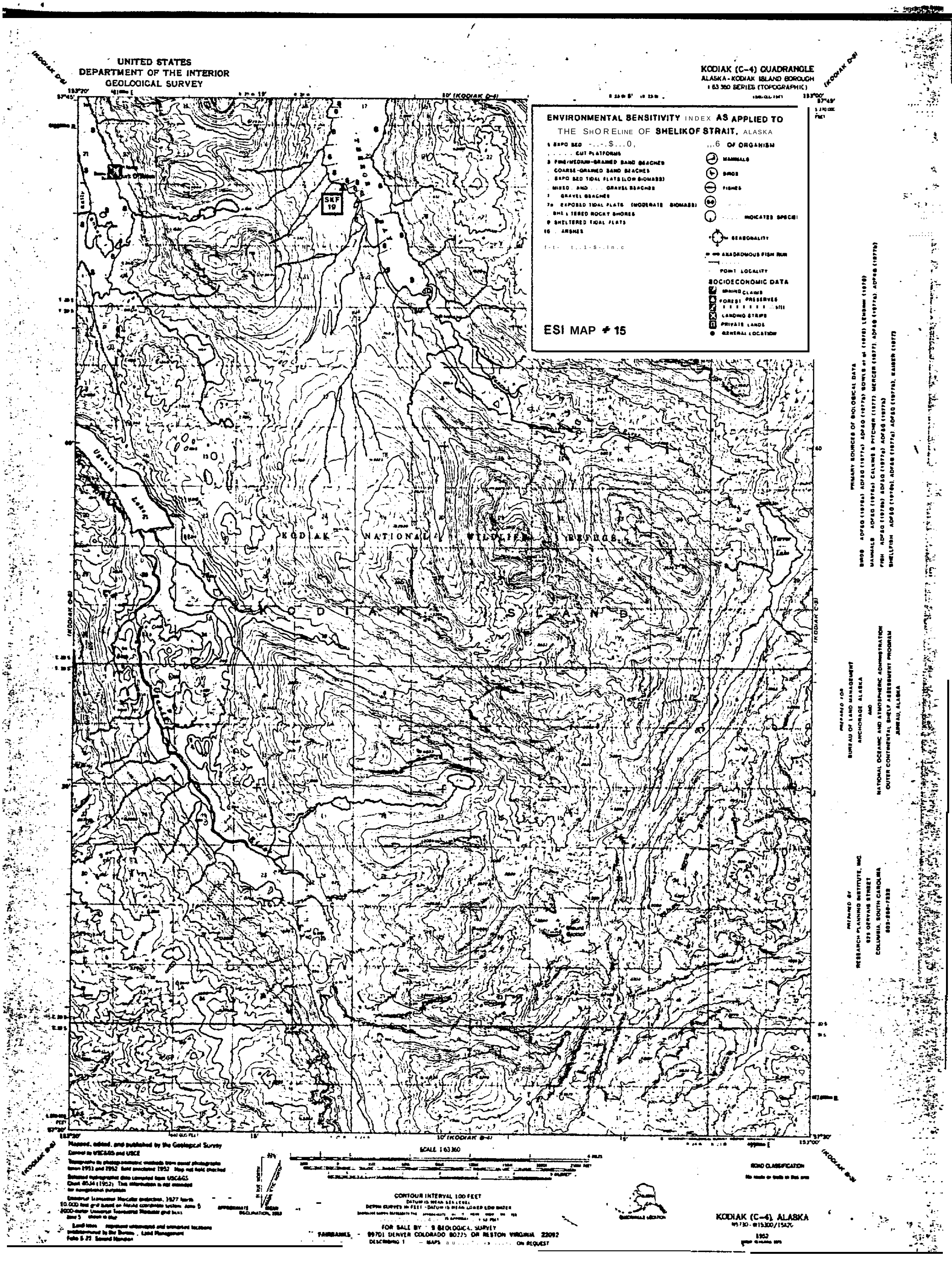
KODIAK (C-5), ALASKA
1952



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KODIAK (C-4) QUADRANGLE
ALASKA-KODIAK ISLAND BOROUGH
1:63 360 SERIES (TOPOGRAPHIC)
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF SHELIKOF STRAIT, ALASKA
CUT PLATFORMS
FINE/MEDIUM-GRAINED SAND BEACHES
COARSE-GRAINED SAND BEACHES
GRAVEL BEACHES
SHELTERED ROCKY SHORES
SHELTERED TIDAL FLATS
OF ORGANISM
MAMMALS
BIRDS
FISHES
INDICATES SPECIES
SEASONALITY
ANADROMOUS FISH RUN
POINT LOCALITY
SOCIOECONOMIC DATA
MINING CLAIMS
FOREST PRESERVES
LANDING STRIPS
PRIVATE LANDS
GENERAL LOCATION
ESI MAP # 15
SKF 19
KODIAK NATIONAL WILDLIFE REFUGE
KODIAK ISLAND
Uganik Lake
PRIMARY SOURCES OF BIOLOGICAL DATA
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KODIAK (C-4), ALASKA
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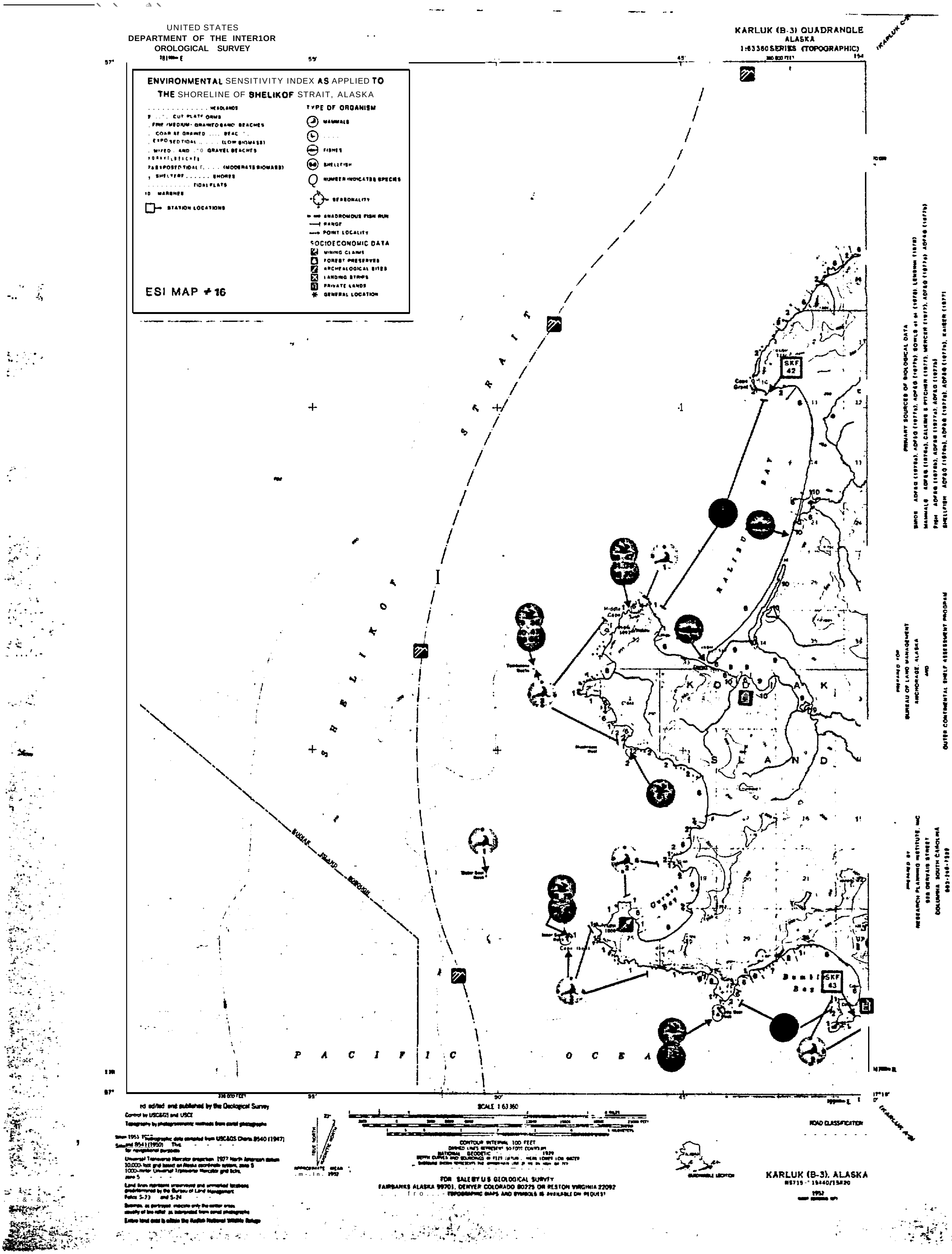
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ALASKA
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ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF SHELIKOF STRAIT, ALASKA
HEADLANDS
CUT PLATFORMS
FINE/MEDIUM-GRAINED SAND BEACHES
COARSE GRAINED BEACHES
EXPOSED TIDAL (LOW BIOMASS)
MIXED SAND AND GRAVEL BEACHES
GRAVEL BEACHES
EXPOSED TIDAL (MODERATE BIOMASS)
SHELTERED SHORES
TIDAL FLATS
10 MARSHES
STATION LOCATIONS
TYPE OF ORGANISM
MAMMALS
FISHES
SHELLFISH
NUMBER INDICATES SPECIES
SEASONALITY
ANADROMOUS FISH RUN
RANGE
POINT LOCALITY
SOCIOECONOMIC DATA
MINING CLAIMS
FOREST PRESERVES
ARCHEALOGICAL SITES
LANDING STRIPS
PRIVATE LANDS
GENERAL LOCATION
ESI MAP # 16
SHELIKOF STRAIT
HALIBUT BAY
KODIAK ISLAND
PACIFIC OCEAN
KODIAK ISLAND BOROUGH
Cape Grant
Middle Cape
Gurney Bay
Bumble Bay
SKF 42
SKF 43
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QUADRANGLE LOCATION
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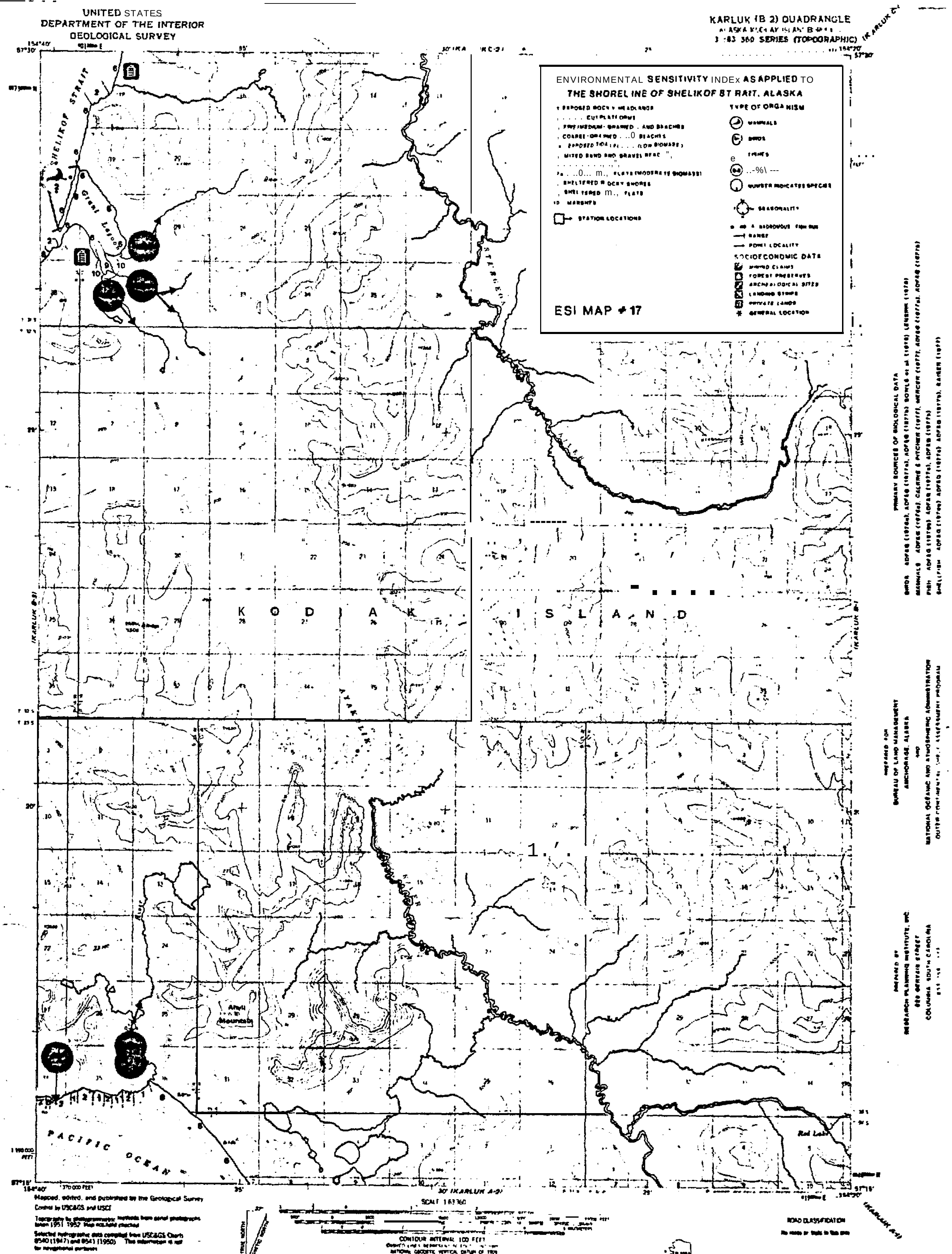

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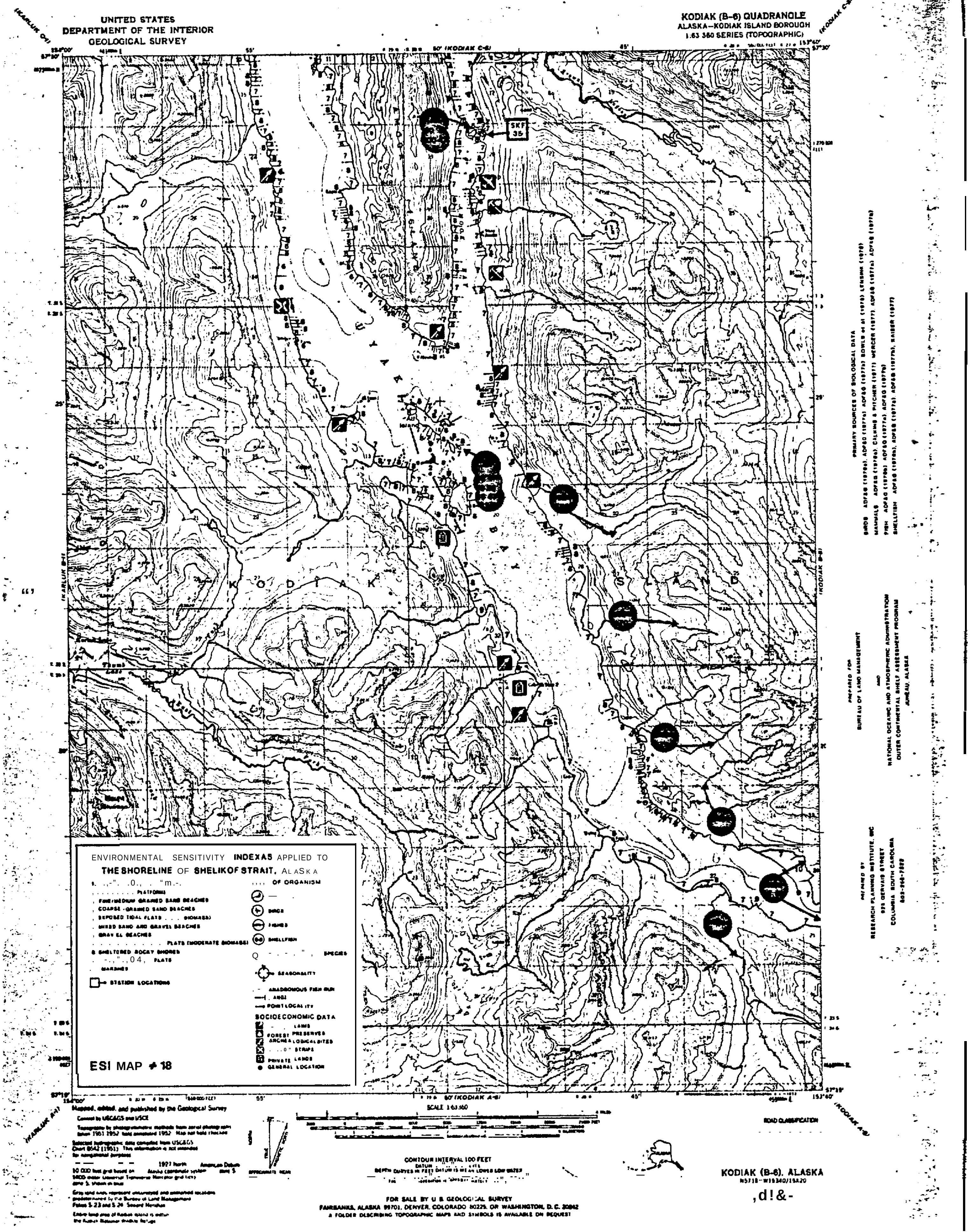
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF SHELIKOF STRAIT, ALASKA
TYPE OF ORGANISM
MAMMALS
BIRDS
FISHES
NUMBER INDICATES SPECIES
SEASONALITY
RANGE
POINT LOCALITY
SOCIOECONOMIC DATA
MINING CLAIMS
FOREST PRESERVES
ARCHEOLOGICAL SITES
LANDING STRIPS
PRIVATE LANDS
GENERAL LOCATION
MARSHES
STATION LOCATIONS
ESI MAP # 17
SHELIKOF STRAIT
K O D I A K I S L A N D
PACIFIC OCEAN
KARLUK (B-2), ALASKA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ALASKA—KODIAK ISLAND BOROUGH
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SKF
35
KODIAK
ENVIRONMENTAL SENSITIVITY INDEXAS APPLIED TO
THE SHORELINE OF SHELIKOF STRAIT, ALASKA
OF ORGANISM
STATION LOCATIONS
SOCIOECONOMIC DATA
ESI MAP # 18
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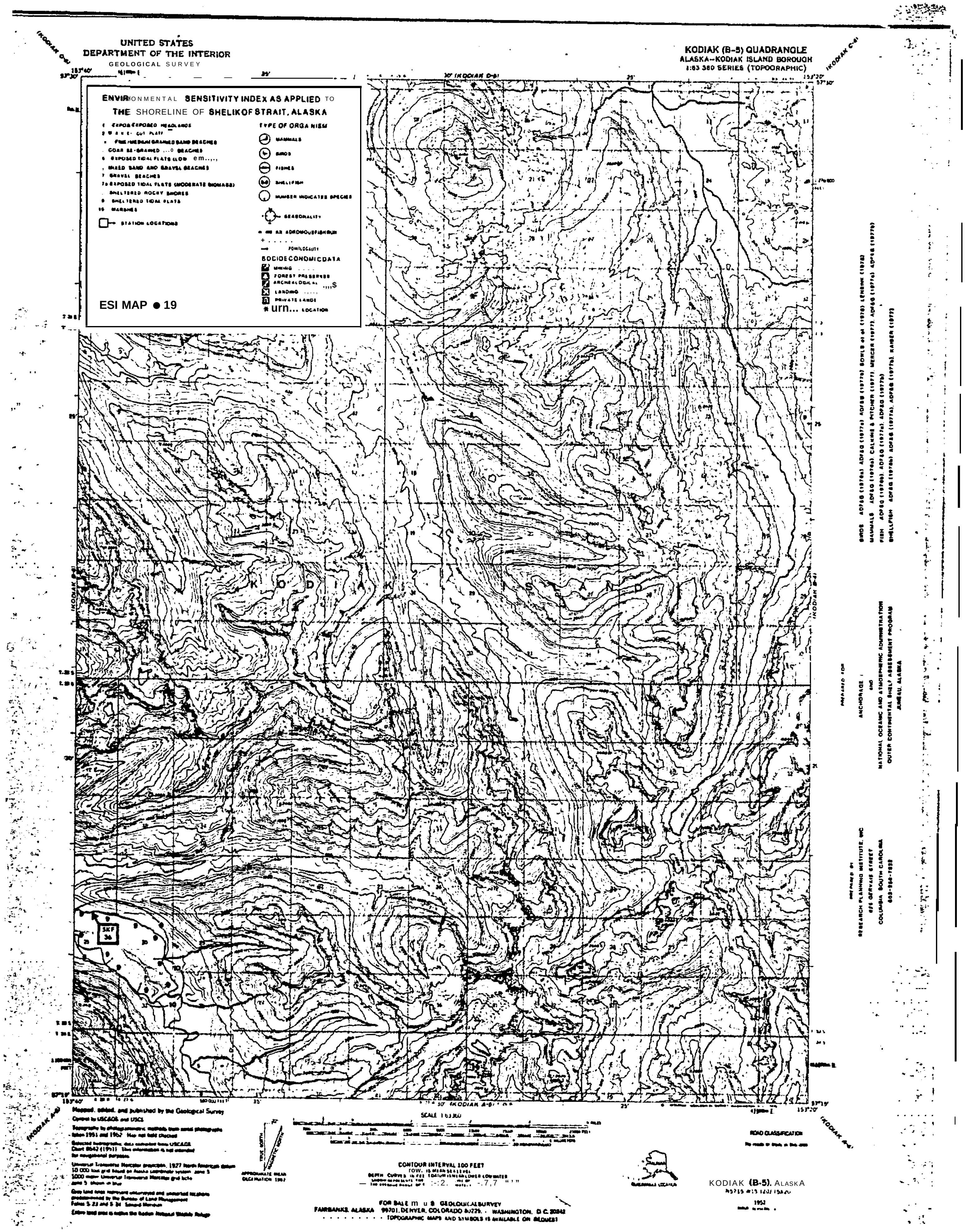

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KODIAK (B-5) QUADRANGLE
ALASKA–KODIAK ISLAND BOROUGH
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ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF SHELIKOF STRAIT, ALASKA
TYPE OF ORGANISM
MAMMALS
BIRDS
FISHES
SHELLFISH
NUMBER INDICATES SPECIES
SEASONALITY
STATION LOCATIONS
SOCIOECONOMIC DATA
ESI MAP ● 19
KODIAK ISLAND
SKF 36
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ROAD CLASSIFICATION
KODIAK (B-5), ALASKA
1952
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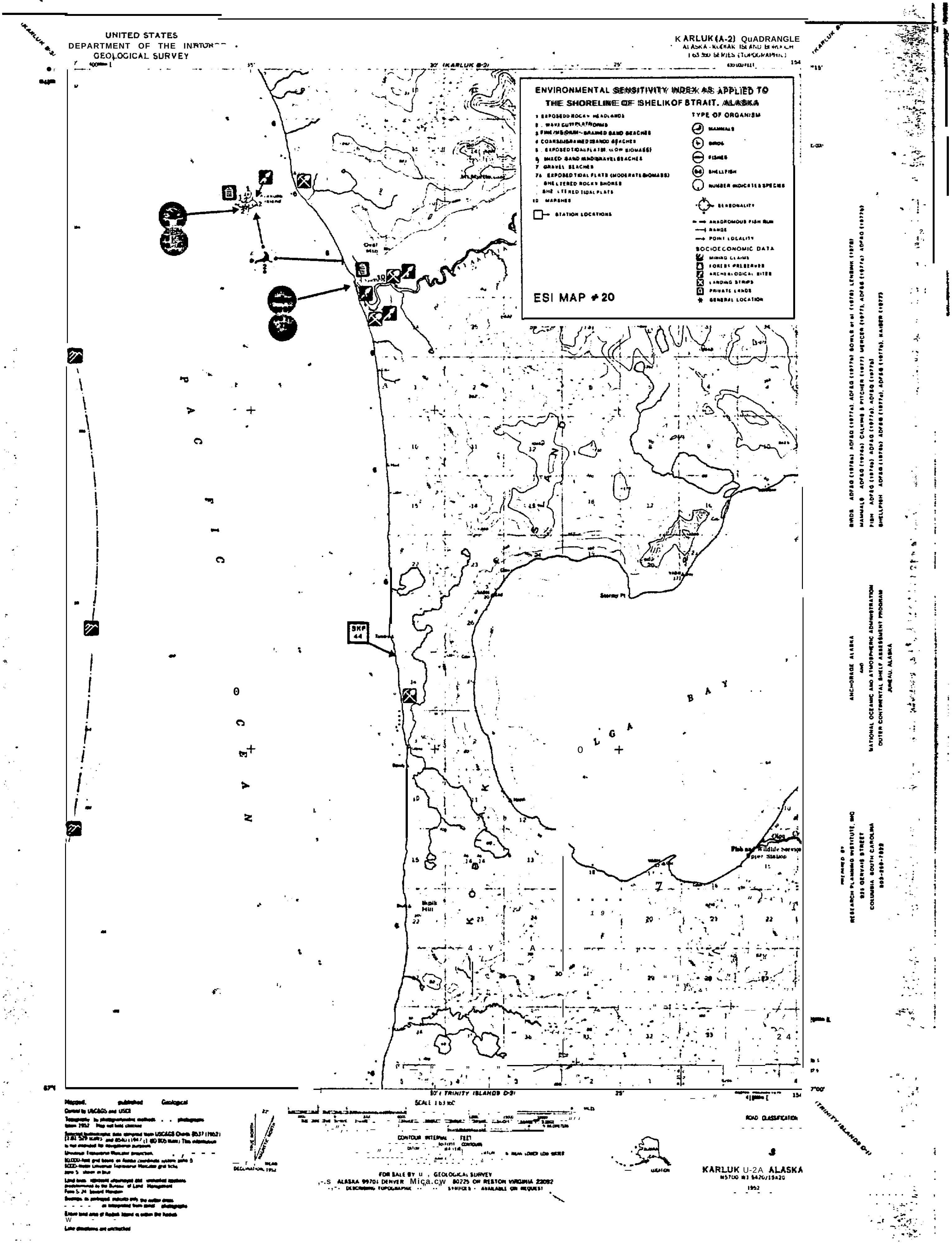
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KARLUK (A-2) QUADRANGLE
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF SHELIKOF STRAIT, ALASKA
TYPE OF ORGANISM
MAMMALS
BIRDS
FISHES
SHELLFISH
NUMBER INDICATES SPECIES
SEASONALITY
ANADROMOUS FISH RUN
RANGE
POINT LOCALITY
SOCIOECONOMIC DATA
MINING CLAIMS
FOREST PRESERVES
ARCHEALOGICAL SITES
LANDING STRIPS
PRIVATE LANDS
GENERAL LOCATION
7 GRAVEL BEACHES
10 MARSHES
STATION LOCATIONS
ESI MAP # 20
P A C I F I C
O C E A N
O L G A
B A Y
Stormy Pt
SKP
44
Fish and Wildlife Service
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KARLUK
ALASKA
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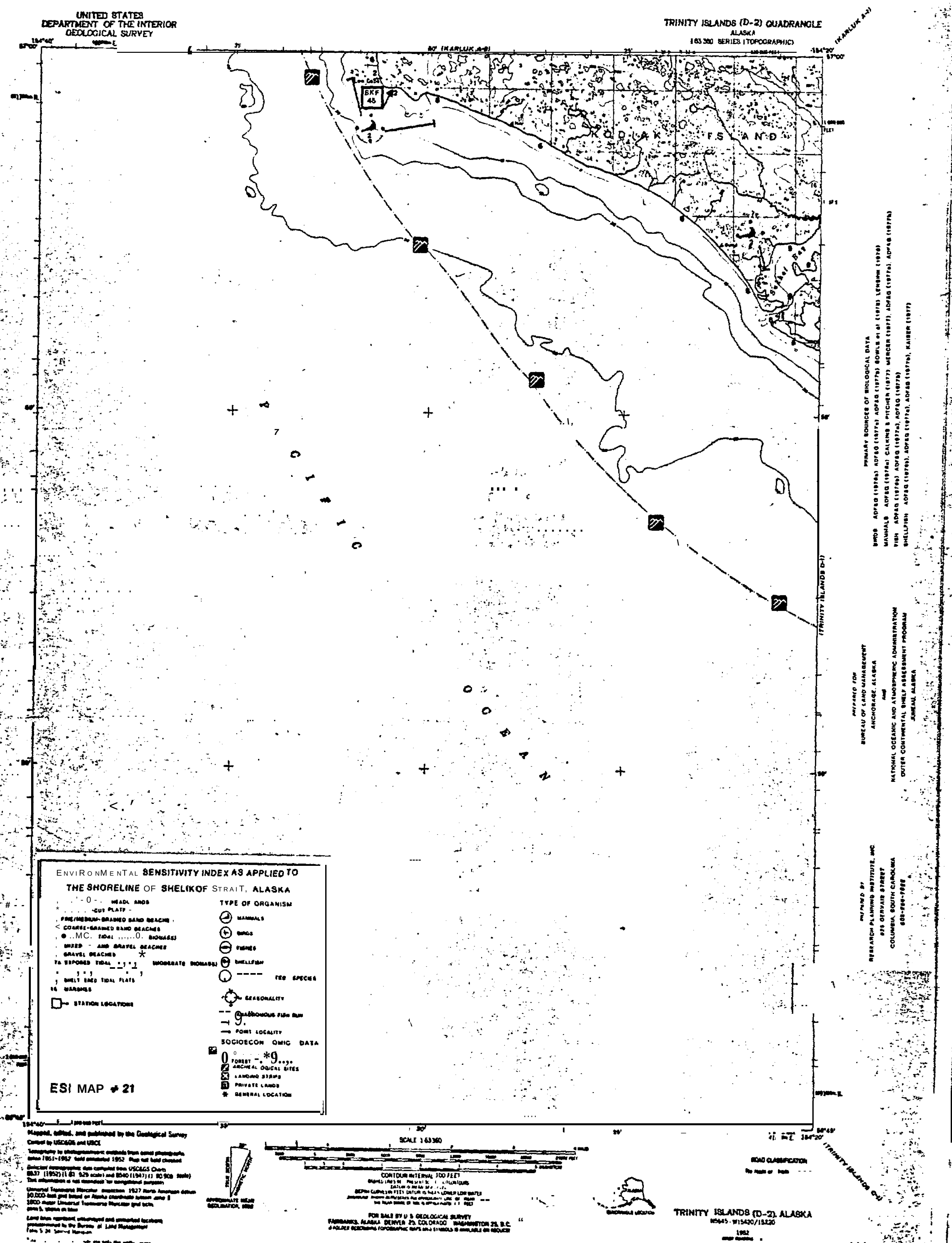

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TRINITY ISLANDS (D-2) QUADRANGLE
ALASKA
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KODIAK ISLAND
PACIFIC OCEAN
BKF 45
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF SHELIKOF STRAIT, ALASKA
TYPE OF ORGANISM
MAMMALS
BIRDS
FISHES
SHELLFISH
SEASONALITY
POINT LOCALITY
SOCIOECONOMIC DATA
STATION LOCATIONS
ARCHEAL OGICAL SITES
PRIVATE LANDS
GENERAL LOCATION
ESI MAP # 21
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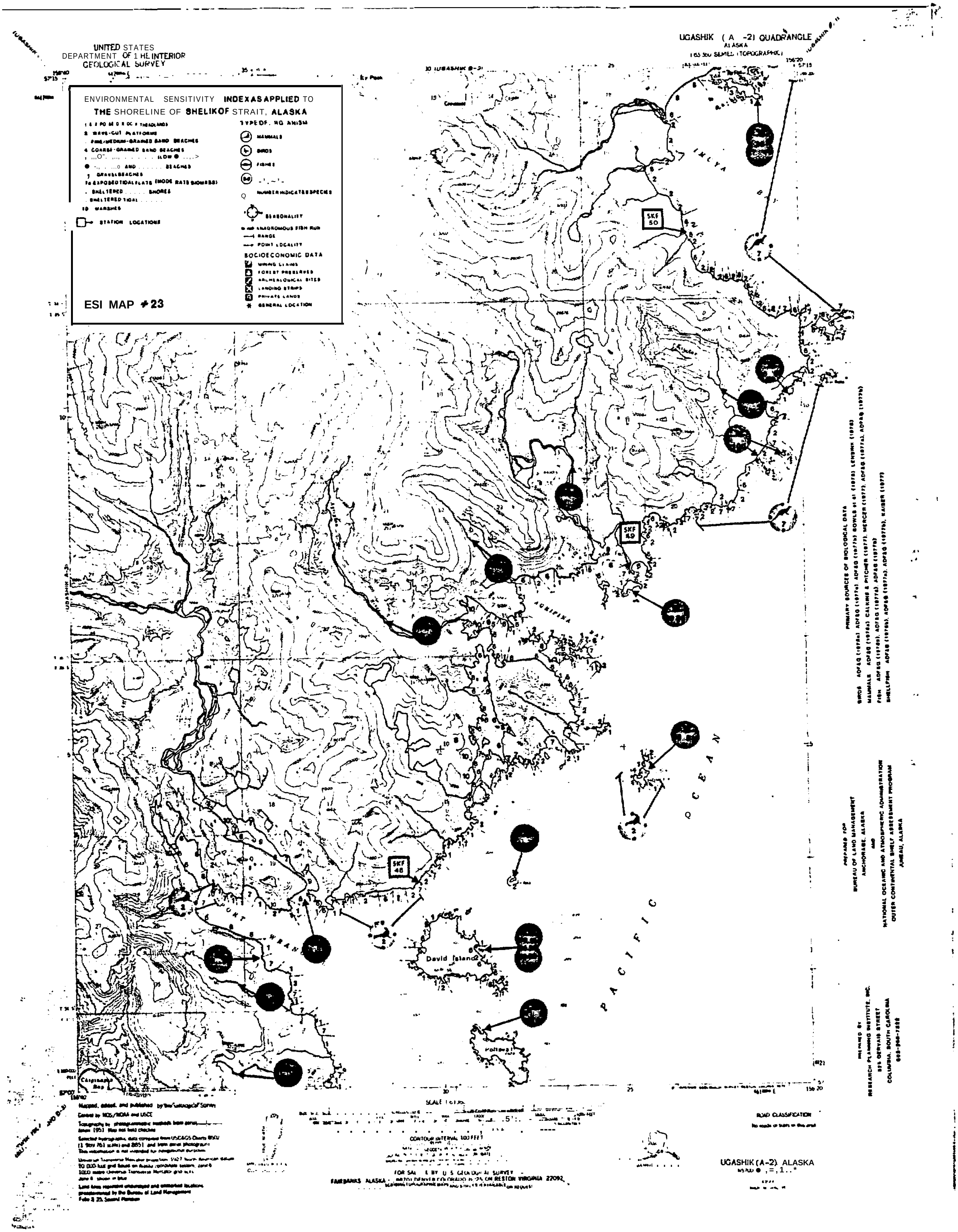
1952



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UGASHIK (A-2) QUADRANGLE
ALASKA
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF SHELIKOF STRAIT, ALASKA
2 WAVE-CUT PLATFORMS
4 COARSE-GRAINED SAND BEACHES
GRAVEL BEACHES
SHELTERED SHORES
10 MARSHES
STATION LOCATIONS
TYPE OF ORGANISM
MAMMALS
BIRDS
FISHES
NUMBER INDICATES SPECIES
SEASONALITY
ANADROMOUS FISH RUN
RANGE
POINT LOCALITY
SOCIOECONOMIC DATA
MINING CLAIMS
FOREST PRESERVES
ARCHEALOGICAL SITES
LANDING STRIPS
PRIVATE LANDS
GENERAL LOCATION
ESI MAP #23
SKF 50
SKF 49
SKF 48
David Island
PACIFIC OCEAN
CONTOUR INTERVAL 100 FEET
UGASHIK (A-2) ALASKA

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ALASKA-KODIAK ISLAND
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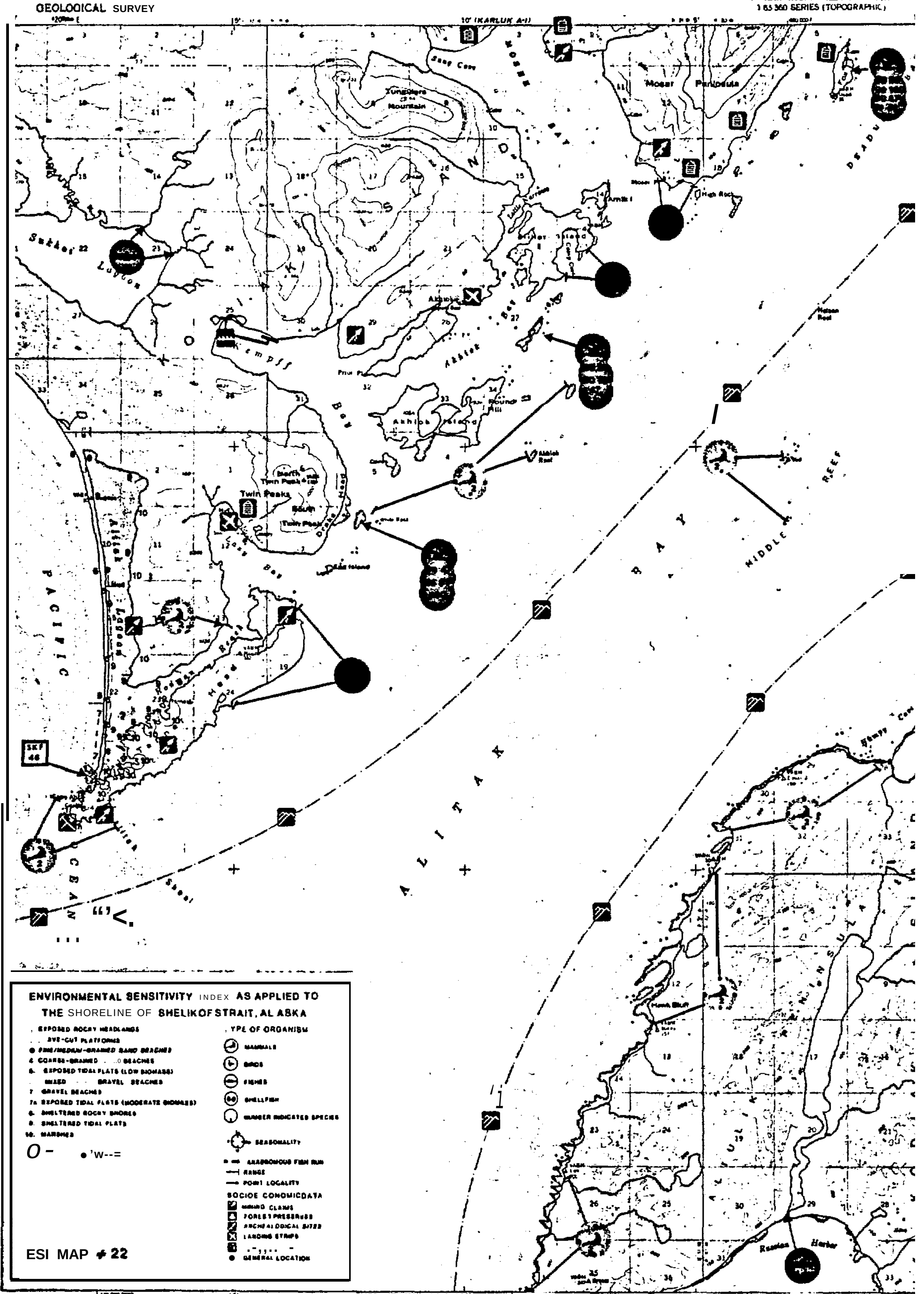

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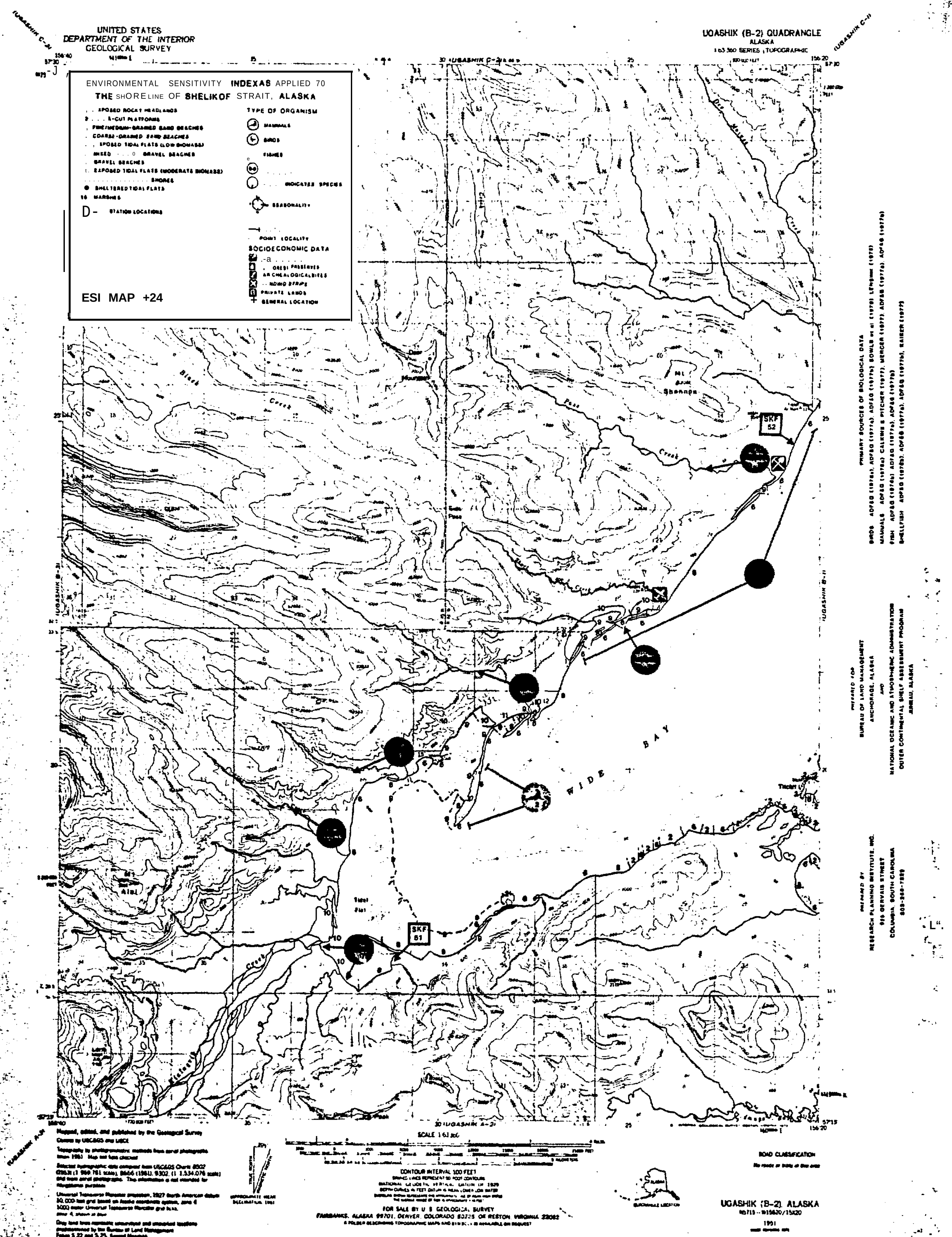
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ALASKA
ENVIRONMENTAL SENSITIVITY INDEXAS APPLIED 70
THE SHORELINE OF SHELIKOF STRAIT, ALASKA
TYPE OF ORGANISM
MAMMALS
BIRDS
FISHES
INDICATES SPECIES
SEASONALITY
POINT LOCALITY
SOCIOECONOMIC DATA
ARCHEALOGICAL SITES
PRIVATE LANDS
GENERAL LOCATION
SHELTERED TIDAL FLATS
MARSHES
STATION LOCATIONS
ESI MAP +24
SKF 52
SKF 51
WIDE BAY
Tidal Flat
Black Creek
Pass Creek
Mt. Shenna
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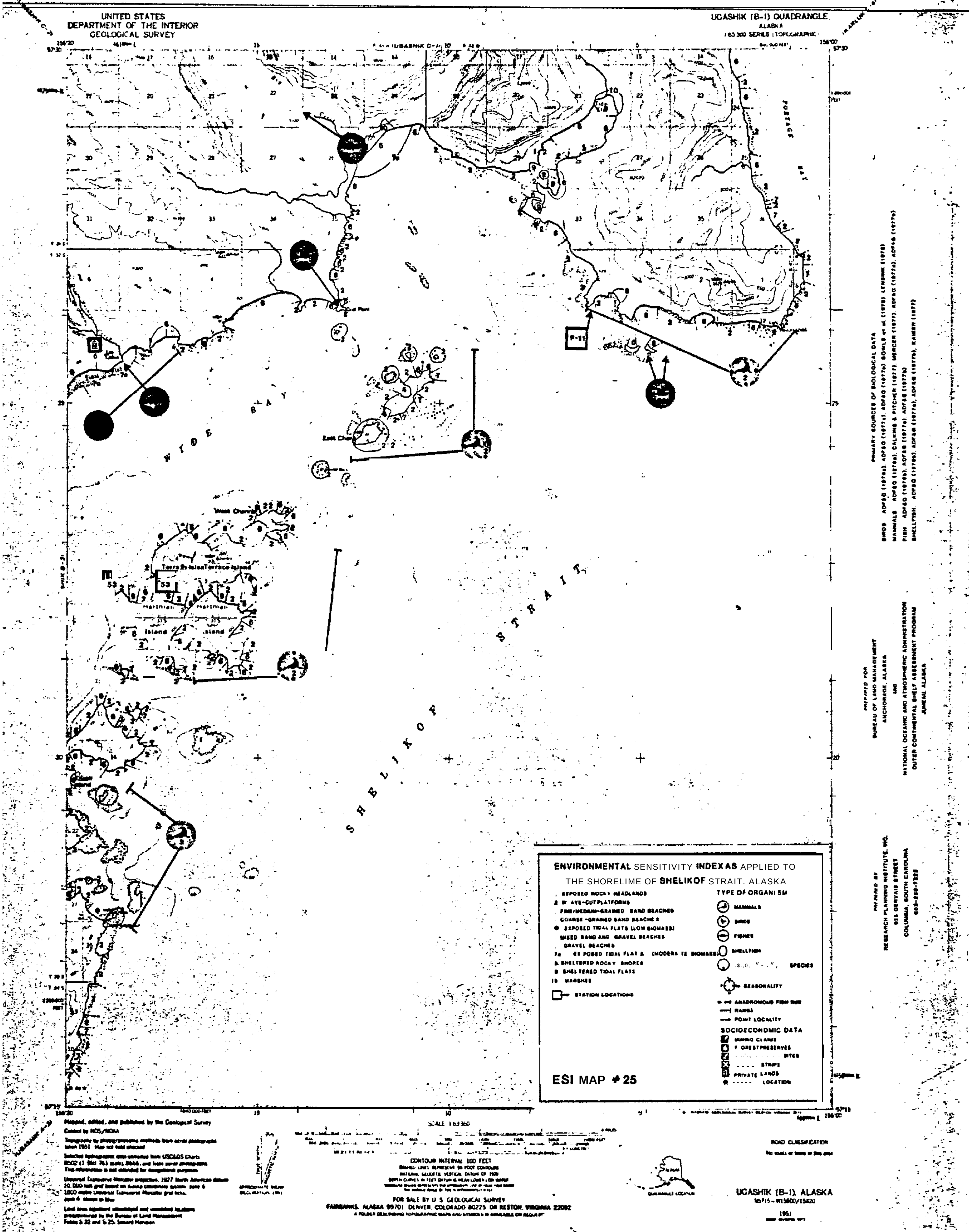
1951



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UGASHIK (B-1) QUADRANGLE
ALASKA
WIDE BAY
SHELIKOF STRAIT
PORTAGE BAY
West Channel
Terrace Island
Martinal Island
P-31
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELIME OF SHELIKOF STRAIT, ALASKA
EXPOSED ROCKY HEADLANDS
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FINE/MEDIUM-GRAINED SAND BEACHES
COARSE-GRAINED SAND BEACHES
EXPOSED TIDAL FLATS (LOW BIOMASS)
MIXED SAND AND GRAVEL BEACHES
GRAVEL BEACHES
EXPOSED TIDAL FLATS (MODERATE BIOMASS)
SHELTERED ROCKY SHORES
SHELTERED TIDAL FLATS
MARSHES
STATION LOCATIONS
TYPE OF ORGANISM
MAMMALS
BIRDS
FISHES
SHELLFISH
SPECIES
SEASONALITY
ANADROMOUS FISH RUN
RANGE
POINT LOCALITY
SOCIOECONOMIC DATA
MINING CLAIMS
FORESTPRESERVES
SITES
STRIPS
PRIVATE LANDS
LOCATION
ESI MAP # 25
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1951

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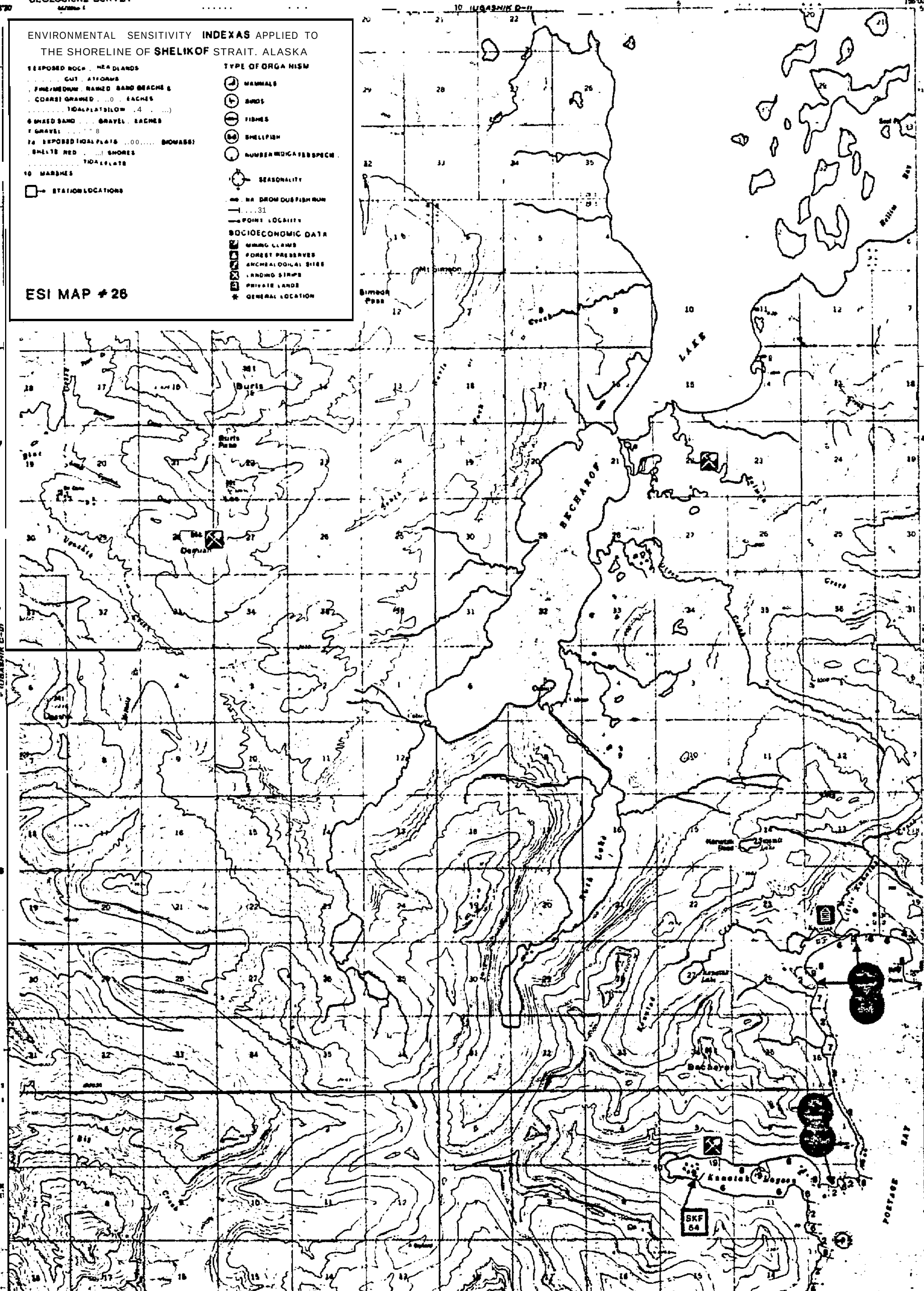
UGASHIK (C-1) QUADRANGLE
ALASKA
1:63 360 SERIES (TOPOGRAPHIC)



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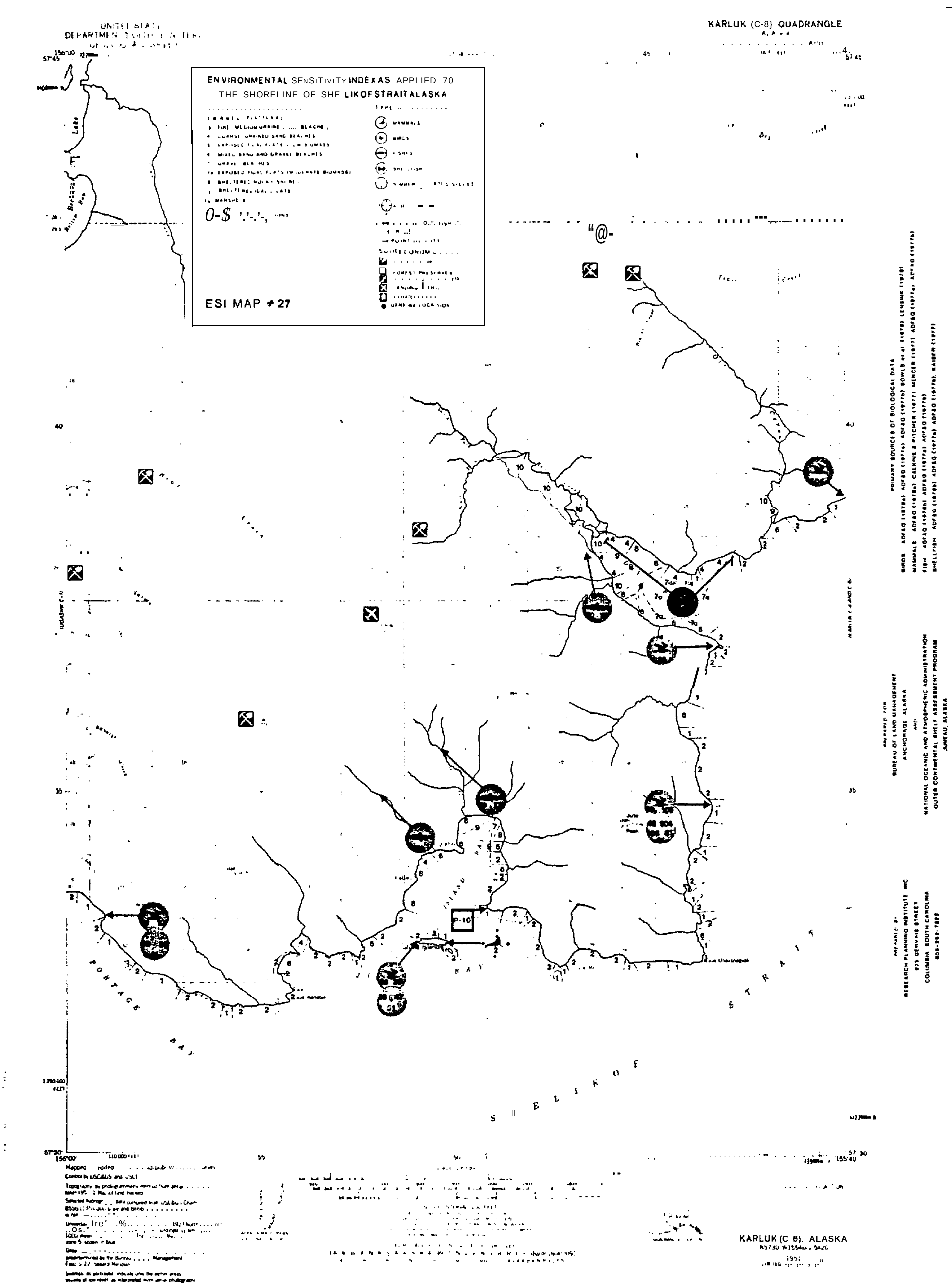

KARLUK (C-8) QUADRANGLE
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF SHELIKOF STRAIT ALASKA
ESI MAP # 27
PRIMARY SOURCES OF BIOLOGICAL DATA
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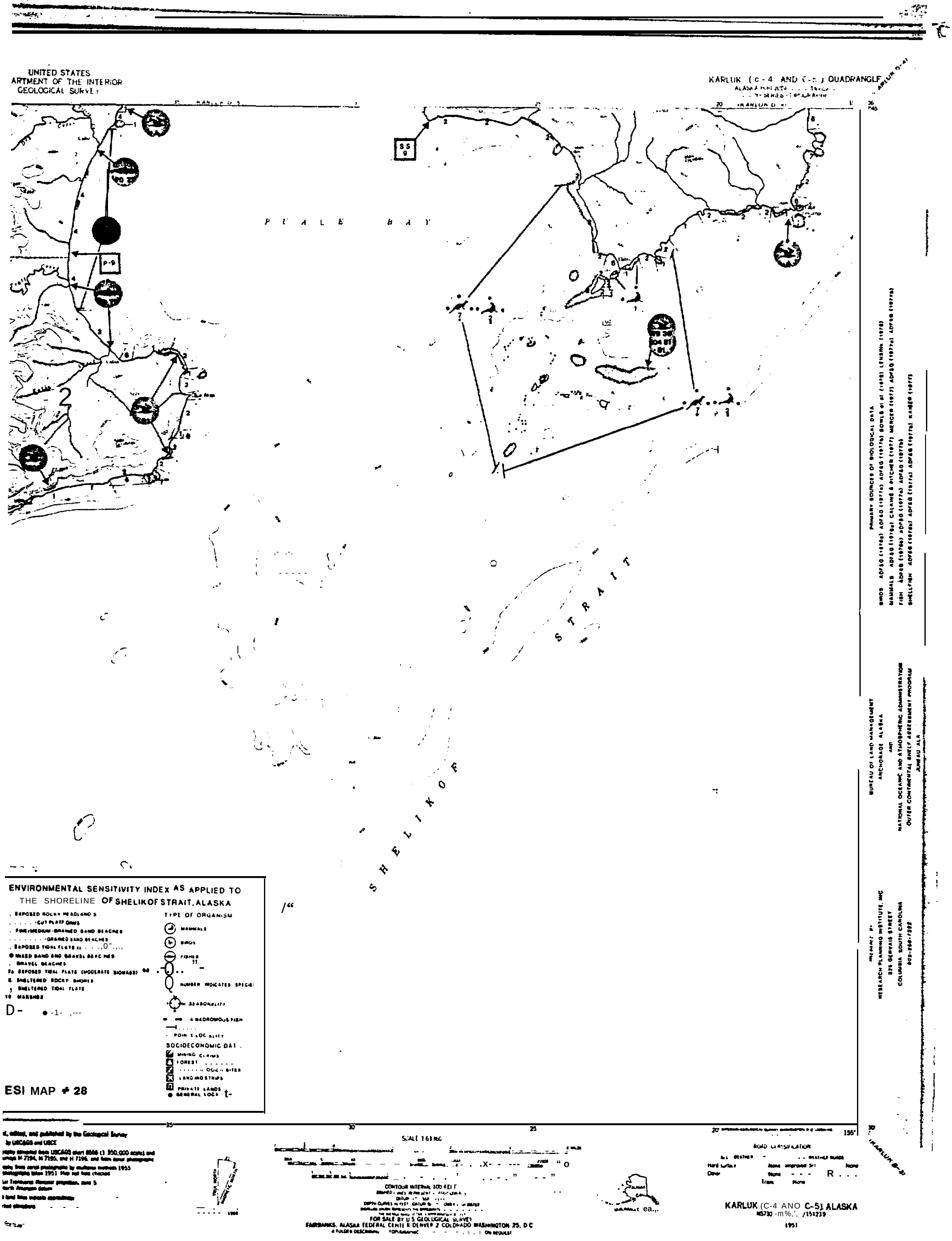
S H E L I K O F S T R A I T
KARLUK (C-8), ALASKA


UNITED STATES
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GEOLOGICAL SURVEY
KARLUK (C-4 AND C-5) QUADRANGLE
P U A L E B A Y
S T R A I T
S H E L I K O F
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF SHELIKOF STRAIT, ALASKA
EXPOSED ROCKY HEADLANDS
MIXED SAND AND GRAVEL BEACHES
GRAVEL BEACHES
SHELTERED ROCKY SHORES
SHELTERED TIDAL FLATS
MARSHES
TYPE OF ORGANISM
MAMMALS
BIRDS
FISHES
NUMBER INDICATES SPECIES
SEASONALITY
ANADROMOUS FISH
SOCIOECONOMIC DATA
MINING CLAIMS
FOREST
LANDING STRIPS
PRIVATE LANDS
GENERAL LOCA
ESI MAP # 28
PRIMARY SOURCES OF BIOLOGICAL DATA
BUREAU OF LAND MANAGEMENT
ANCHORAGE ALASKA
AND
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
OUTER CONTINENTAL SHELF ASSESSMENT PROGRAM
JUNEAU ALA
RESEARCH PLANNING INSTITUTE, INC
COLUMBIA SOUTH CAROLINA
SCALE 1:63 360
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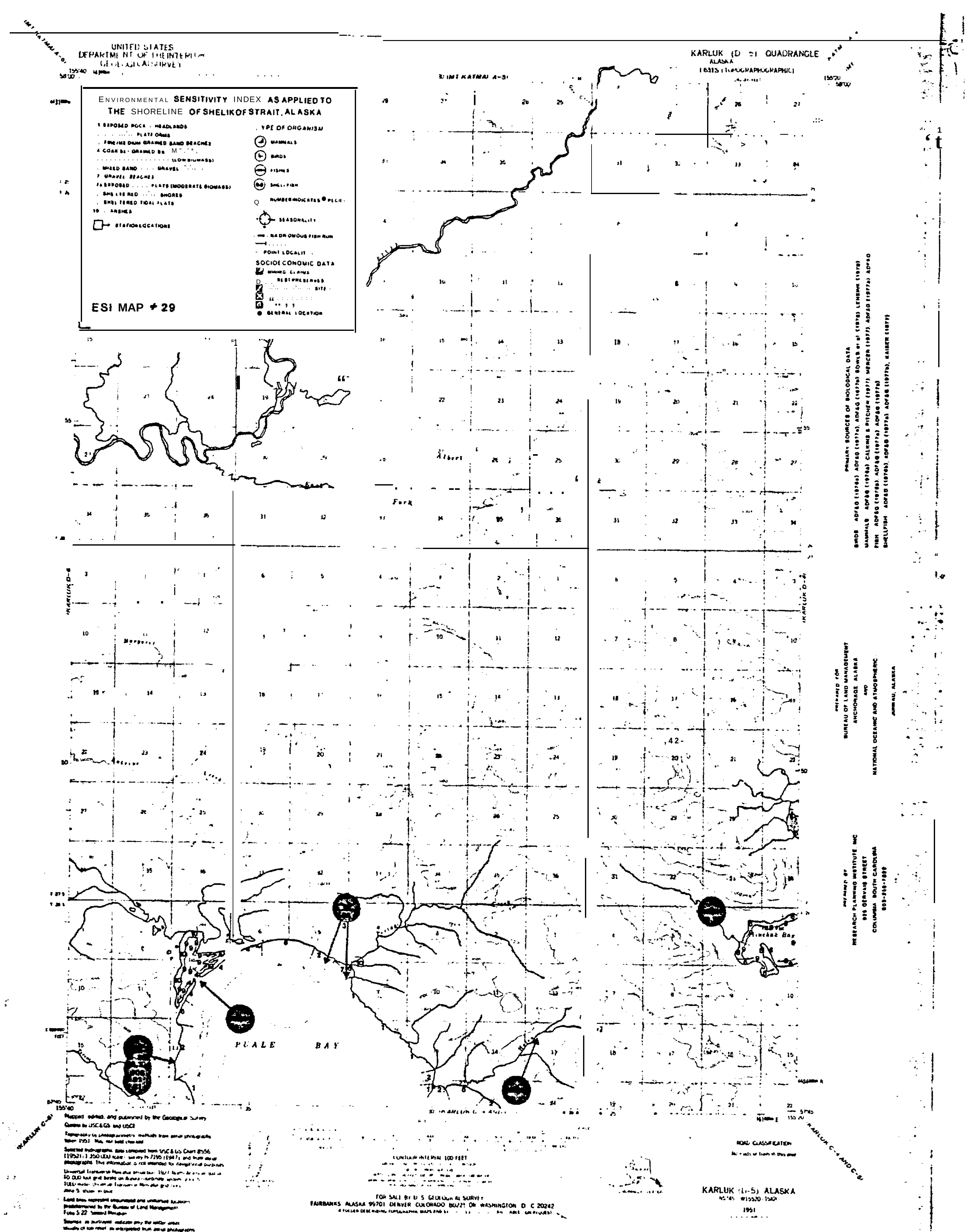
FAIRBANKS, ALASKA FEDERAL CENTER DENVER 2 COLORADO WASHINGTON 25, D C
ROAD CLASSIFICATION
KARLUK (C-4 AND C-5) ALASKA
1951


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
KARLUK (D-5) QUADRANGLE
ALASKA
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF SHELIKOF STRAIT, ALASKA
TYPE OF ORGANISM
MAMMALS
BIRDS
FISHES
SHELLFISH
SEASONALITY
SOCIOECONOMIC DATA
GENERAL LOCATION
ESI MAP # 29
PUALE BAY
Albert
Fork
PRIMARY SOURCES OF BIOLOGICAL DATA
PREPARED FOR
BUREAU OF LAND MANAGEMENT
ANCHORAGE, ALASKA
AND
NATIONAL OCEANIC AND ATMOSPHERIC
JUNEAU, ALASKA
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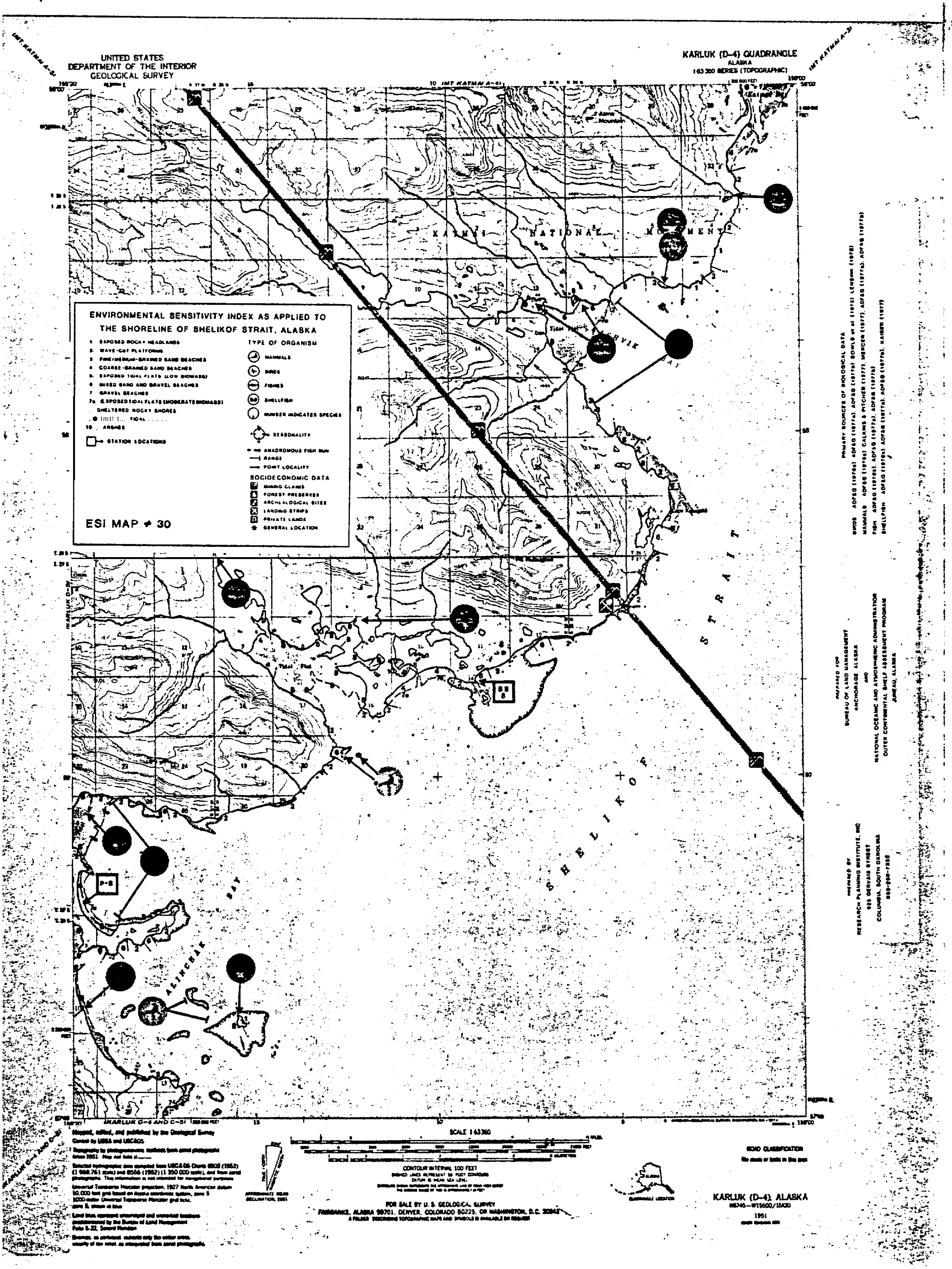
ROAD CLASSIFICATION
KARLUK (D-5), ALASKA
1951


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
KARLUK (D-4) QUADRANGLE
ALASKA
1:63 360 SERIES (TOPOGRAPHIC)
KATMAI NATIONAL MONUMENT
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF SHELIKOF STRAIT, ALASKA
1 EXPOSED ROCKY HEADLANDS
2 WAVE-CUT PLATFORMS
3 FINE/MEDIUM-GRAINED SAND BEACHES
4 COARSE-GRAINED SAND BEACHES
5 EXPOSED TIDAL FLATS (LOW BIOMASS)
6 MIXED SAND AND GRAVEL BEACHES
7 GRAVEL BEACHES
7a EXPOSED TIDAL FLATS (MODERATE BIOMASS)
SHELTERED ROCKY SHORES
10 MARSHES
STATION LOCATIONS
TYPE OF ORGANISM
MAMMALS
BIRDS
FISHES
SHELLFISH
NUMBER INDICATES SPECIES
SEASONALITY
ANADROMOUS FISH RUN
RANGE
POINT LOCALITY
SOCIOECONOMIC DATA
MINING CLAIMS
FOREST PRESERVES
ARCHAEOLOGICAL SITES
LANDING STRIPS
PRIVATE LANDS
GENERAL LOCATION
ESI MAP # 30
SHELIKOF STRAIT
Tidal Flat
PRIMARY SOURCES OF BIOLOGICAL DATA
PREPARED FOR
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ANCHORAGE, ALASKA
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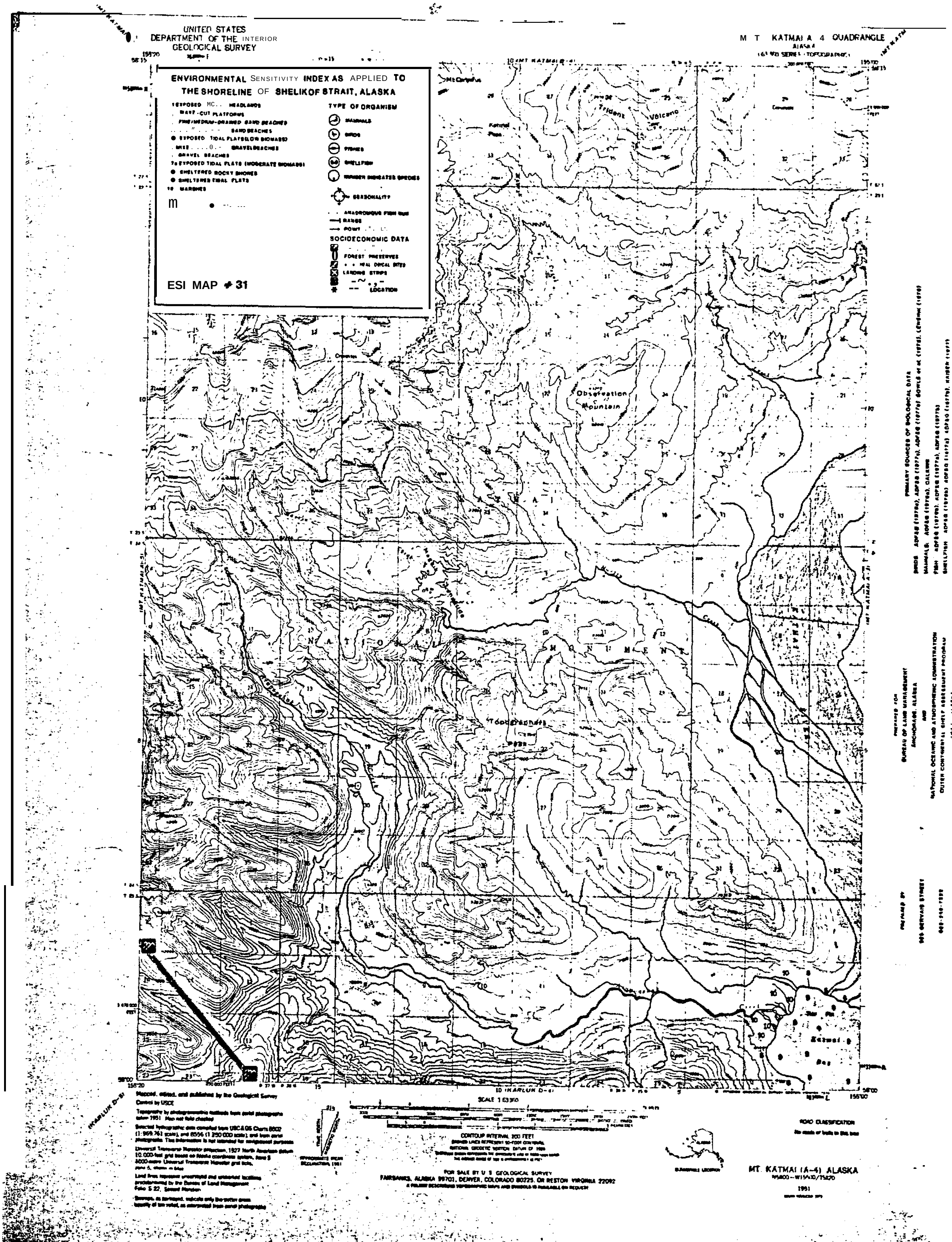
ROAD CLASSIFICATION
KARLUK (D-4), ALASKA
1951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MT. KATMAI A-4 QUADRANGLE
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF SHELIKOF STRAIT, ALASKA
TYPE OF ORGANISM
MAMMALS
BIRDS
FISHES
SHELLFISH
SEASONALITY
SOCIOECONOMIC DATA
ESI MAP # 31
Trident Volcano
Observation Mountain
NATIONAL MONUMENT
Katmai Bay
PRIMARY SOURCES OF BIOLOGICAL DATA
PREPARED FOR BUREAU OF LAND MANAGEMENT ANCHORAGE, ALASKA AND NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION OUTER CONTINENTAL SHELF ASSESSMENT PROGRAM
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ROAD CLASSIFICATION
No roads or trails in this area
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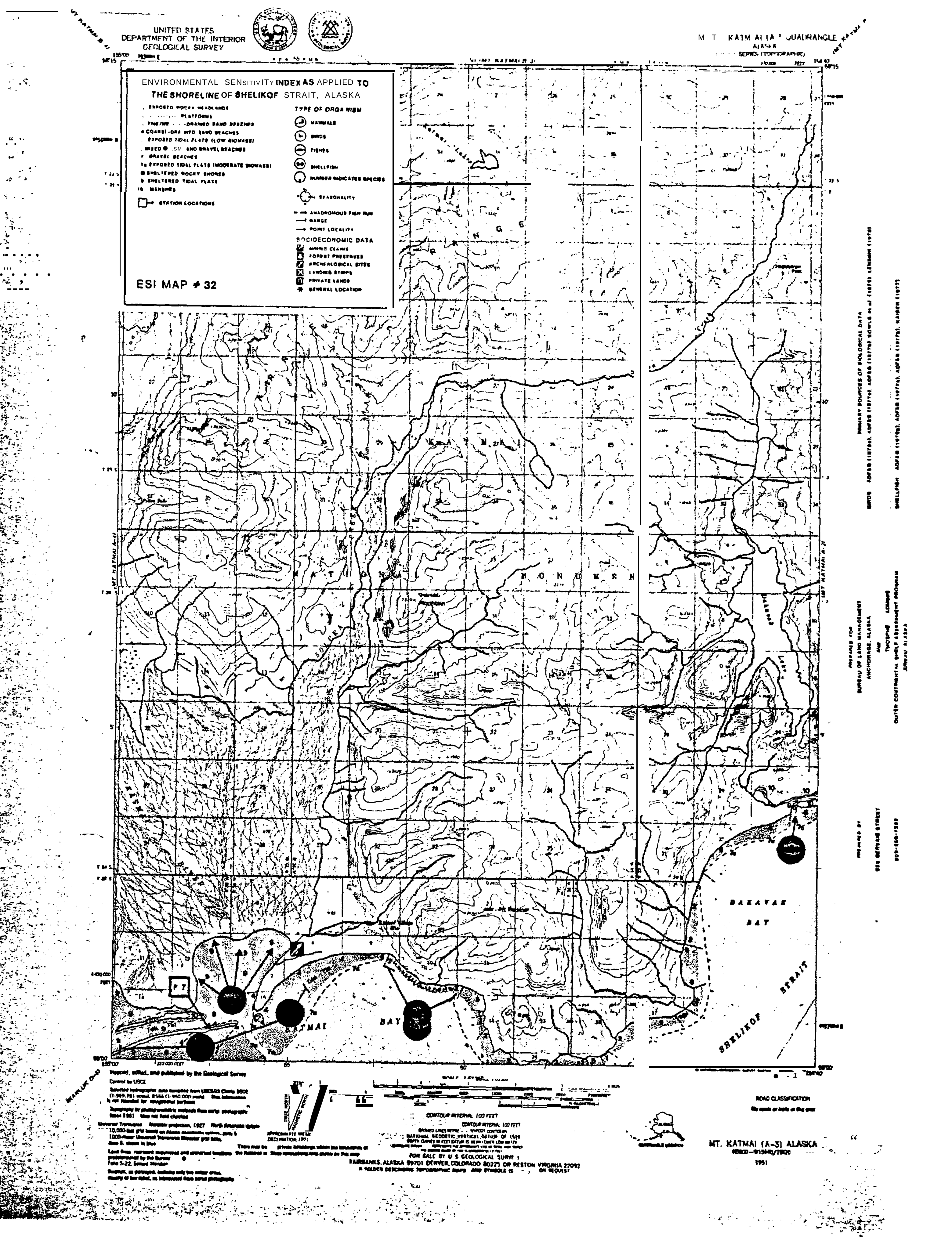
1951


UNITED STATES
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ALASKA
SERIES (TOPOGRAPHIC)
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF SHELIKOF STRAIT, ALASKA
TYPE OF ORGANISM
MAMMALS
BIRDS
FISHES
SHELLFISH
NUMBER INDICATES SPECIES
SEASONALITY
ANADROMOUS FISH RUN
RANGE
POINT LOCALITY
SOCIOECONOMIC DATA
MINING CLAIMS
FOREST PRESERVES
ARCHEOLOGICAL SITES
LANDING STRIPS
PRIVATE LANDS
GENERAL LOCATION
EXPOSED ROCKY HEADLANDS
PLATFORMS
FINE/MED GRAINED SAND BEACHES
COARSE-GRAINED SAND BEACHES
EXPOSED TIDAL FLATS (LOW BIOMASS)
MIXED SAND AND GRAVEL BEACHES
GRAVEL BEACHES
EXPOSED TIDAL FLATS (MODERATE BIOMASS)
SHELTERED ROCKY SHORES
SHELTERED TIDAL FLATS
MARSHES
STATION LOCATIONS
ESI MAP # 32
KATMAI
BAY
DAKAVAK
BAY
SHELIKOF
STRAIT
CONTOUR INTERVAL 100 FEET
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ROAD CLASSIFICATION
MT. KATMAI (A-3) ALASKA
1951
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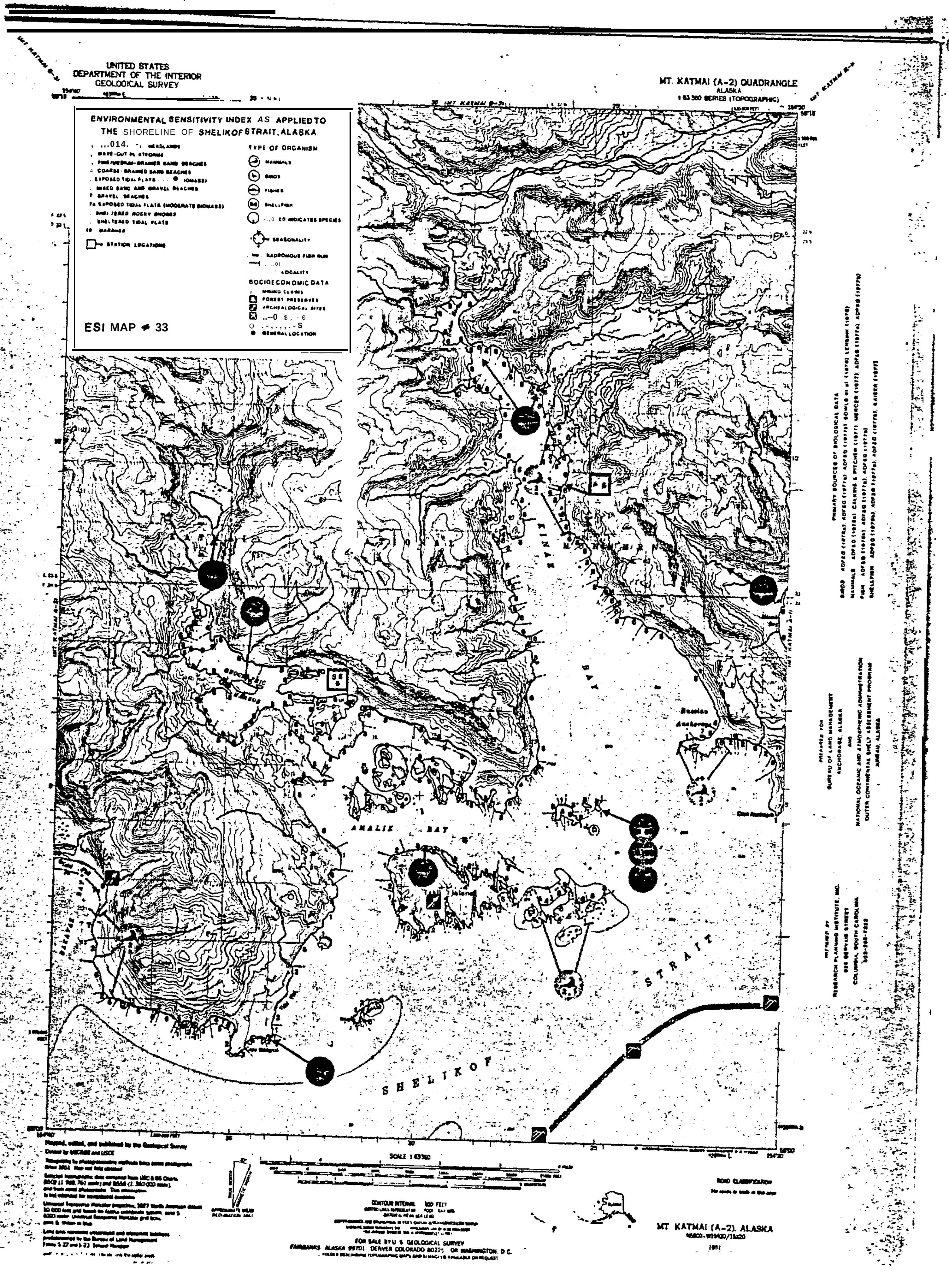
OUTER CONTINENTAL SHELF ASSESSMENT PROGRAM
JUNEAU, ALASKA
PRIMARY SOURCES OF BIOLOGICAL DATA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GEOLOGICAL SURVEY
MT. KATMAI (A-2) QUADRANGLE
ALASKA
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF SHELIKOF STRAIT, ALASKA
COARSE-GRAINED SAND BEACHES
EXPOSED TIDAL FLATS
MIXED SAND AND GRAVEL BEACHES
GRAVEL BEACHES
EXPOSED TIDAL FLATS (MODERATE BIOMASS)
SHELTERED ROCKY SHORES
SHELTERED TIDAL FLATS
MARSHES
STATION LOCATIONS
TYPE OF ORGANISM
MAMMALS
BIRDS
FISHES
SHELLFISH
SEASONALITY
LOCALITY
SOCIOECONOMIC DATA
FOREST PRESERVES
ARCHEALOGICAL SITES
GENERAL LOCATION
ESI MAP # 33
KINAK
BAY
AMALIK BAY
SHELIKOF
STRAIT
Russian Anchorage
PRIMARY SOURCES OF BIOLOGICAL DATA
PREPARED FOR
BUREAU OF LAND MANAGEMENT
ANCHORAGE, ALASKA
AND
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
OUTER CONTINENTAL SHELF ASSESSMENT PROGRAM
JUNEAU, ALASKA
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CONTOUR INTERVAL 100 FEET
ROAD CLASSIFICATION
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MT. KATMAI (A-2), ALASKA
1951

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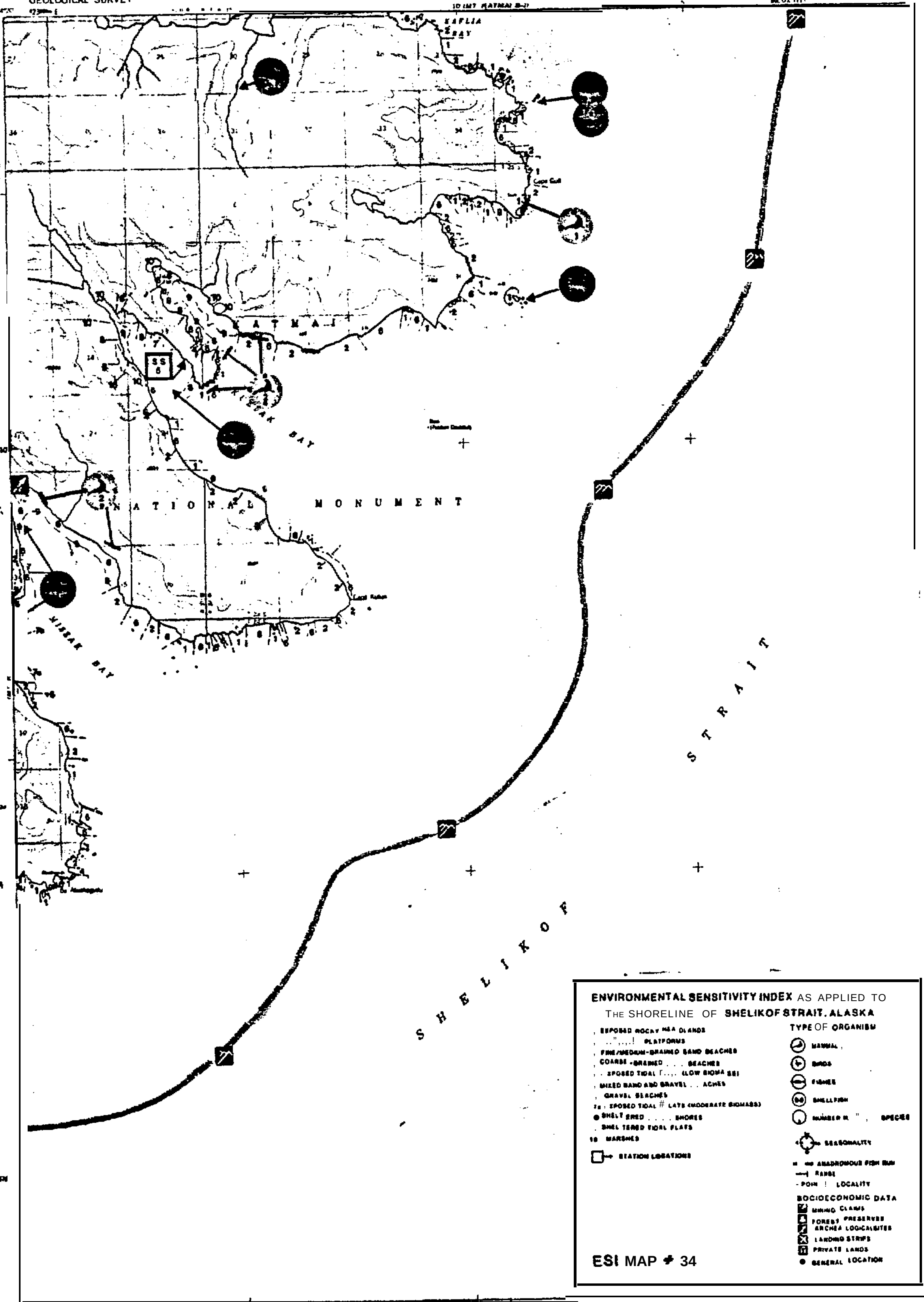
MT. KATMAI (A-1) QUADRANGLE
ALASKA
1:63 360 SERIES (TOPOGRAPHIC)



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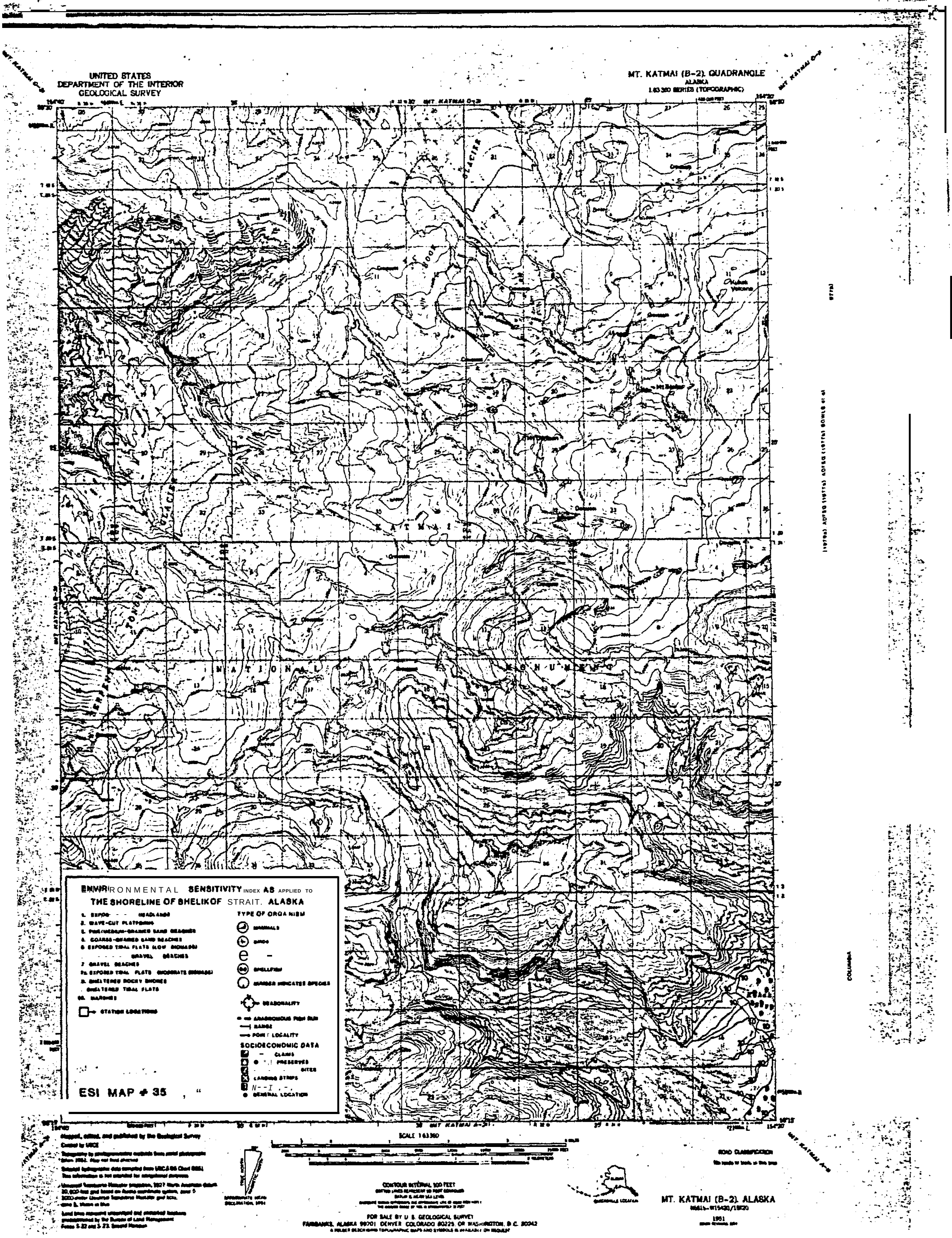
1951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ALASKA
1:63 360 SERIES (TOPOGRAPHIC)
KATMAI
NATIONAL
MONUMENT
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF SHELIKOF STRAIT, ALASKA
2. WAVE-CUT PLATFORMS
4. COARSE-GRAINED SAND BEACHES
7 GRAVEL BEACHES
TYPE OF ORGANISM
SHELLFISH
SEASONALITY
SOCIOECONOMIC DATA
CLAIMS
PRESERVES
SITES
LANDING STRIPS
GENERAL LOCATION
ESI MAP # 35
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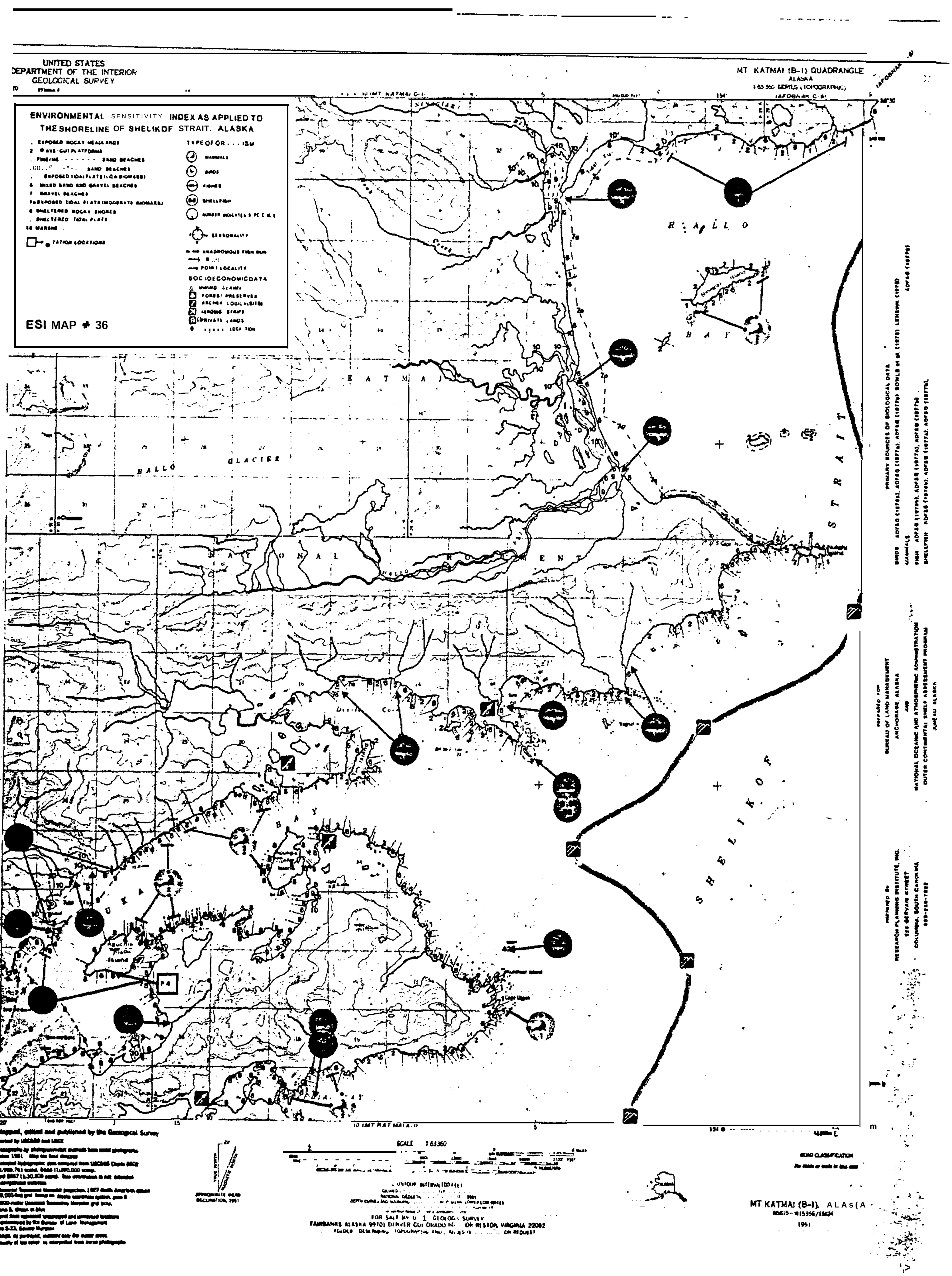
MT. KATMAI (B-2), ALASKA
1951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MT KATMAI (B-1) QUADRANGLE
ALASKA
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO THE SHORELINE OF SHELIKOF STRAIT, ALASKA
TYPE OF OR . . . ISM
MAMMALS
BIRDS
FISHES
SHELLFISH
SEASONALITY
ANADROMOUS FISH RUN
SOCIOECONOMIC DATA
FOREST PRESERVES
PRIVATE LANDS
ESI MAP # 36
K A T M A I
HALLO
GLACIER
H A L L O
B A Y
S T R A I T
S H E L I K O F
PRIMARY SOURCES OF BIOLOGICAL DATA
PREPARED FOR
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ANCHORAGE, ALASKA
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JUNEAU, ALASKA
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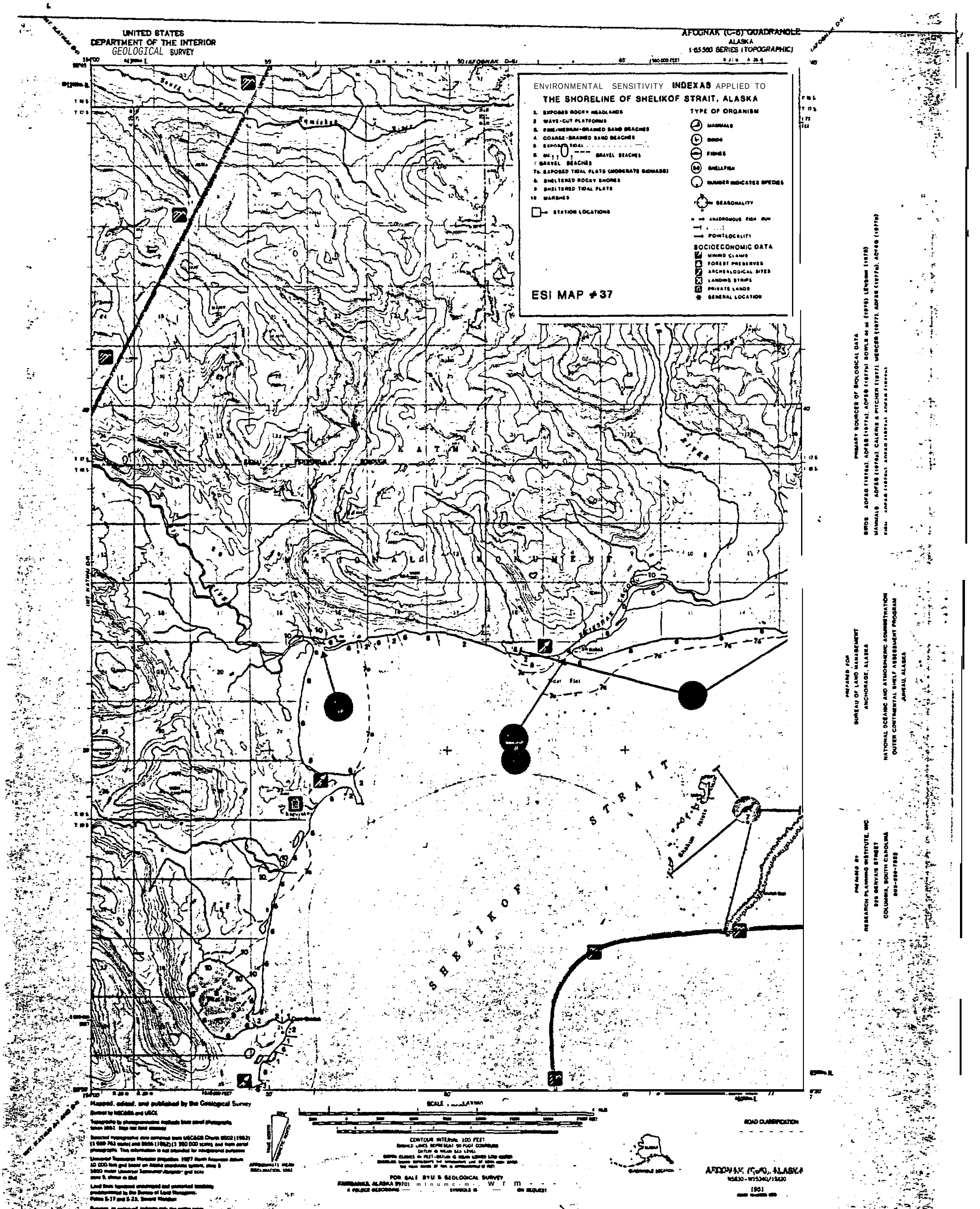
ROAD CLASSIFICATION
MT KATMAI (B-1), ALASKA
1951



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GEOLOGICAL SURVEY
AFOGNAK (C-6) QUADRANGLE
ALASKA
1:63 360 SERIES (TOPOGRAPHIC)
ENVIRONMENTAL SENSITIVITY INDEXAS APPLIED TO
THE SHORELINE OF SHELIKOF STRAIT, ALASKA
1. EXPOSED ROCKY HEADLANDS
2. WAVE-CUT PLATFORMS
3. FINE/MEDIUM-GRAINED SAND BEACHES
4. COARSE-GRAINED SAND BEACHES
5. EXPOSED TIDAL
6. GRAVEL BEACHES
7. GRAVEL BEACHES
7a. EXPOSED TIDAL FLATS (MODERATE BIOMASS)
8. SHELTERED ROCKY SHORES
9. SHELTERED TIDAL FLATS
10. MARSHES
STATION LOCATIONS
TYPE OF ORGANISM
MAMMALS
BIRDS
FISHES
SHELLFISH
NUMBER INDICATES SPECIES
SEASONALITY
ANADROMOUS FISH RUN
POINT LOCALITY
SOCIOECONOMIC DATA
MINING CLAIMS
FOREST PRESERVES
ARCHAEOLOGICAL SITES
LANDING STRIPS
PRIVATE LANDS
GENERAL LOCATION
ESI MAP #37
KATMAI
NATIONAL MONUMENT
SHELIKOF STRAIT
PREPARED FOR
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NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
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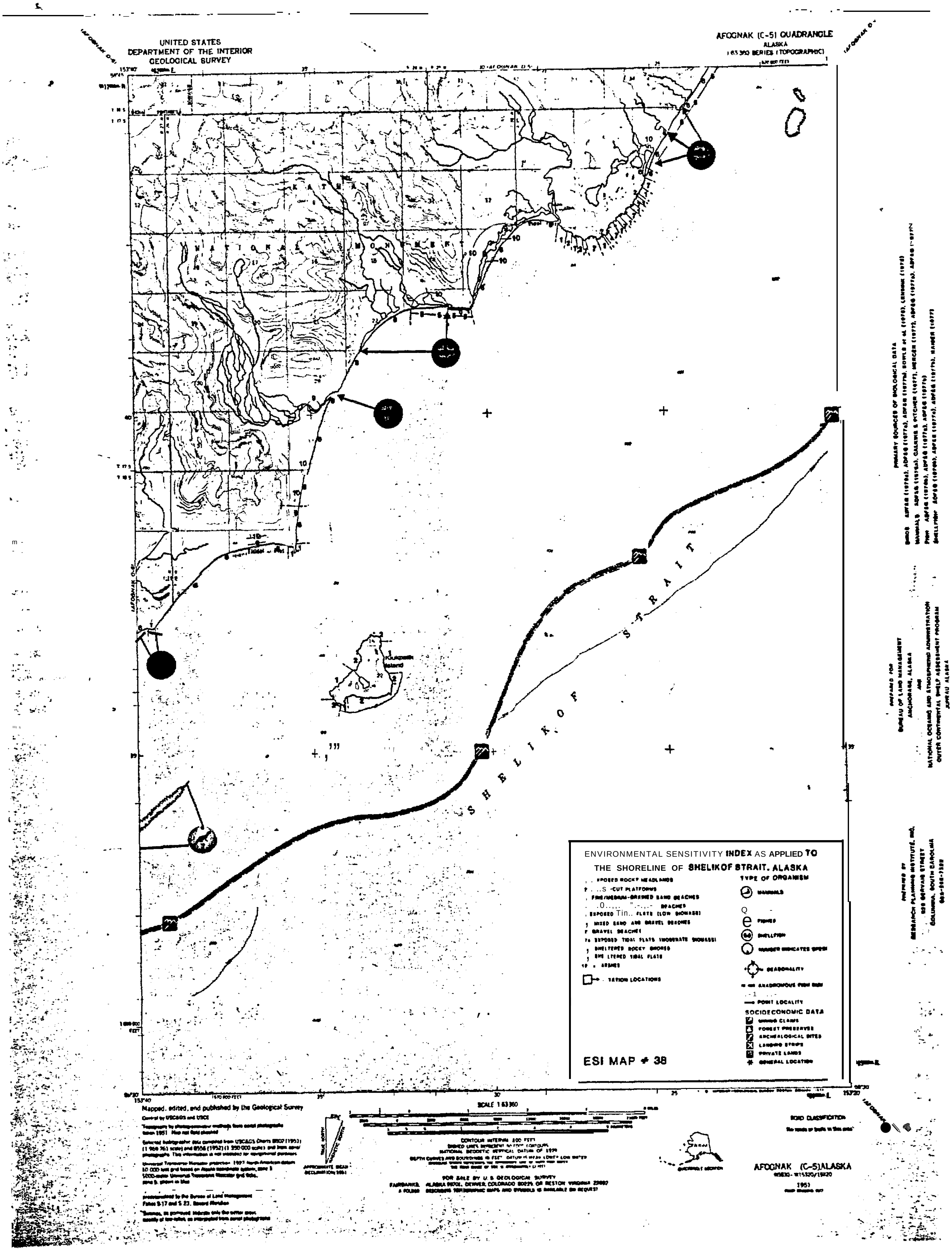
ROAD CLASSIFICATION
AFOGNAK (C-6), ALASKA
1951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ALASKA
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Kiukpalik Island
SHELIKOF STRAIT
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF SHELIKOF STRAIT, ALASKA
TYPE OF ORGANISM
SOCIOECONOMIC DATA
ESI MAP # 38
SCALE 1:63 360
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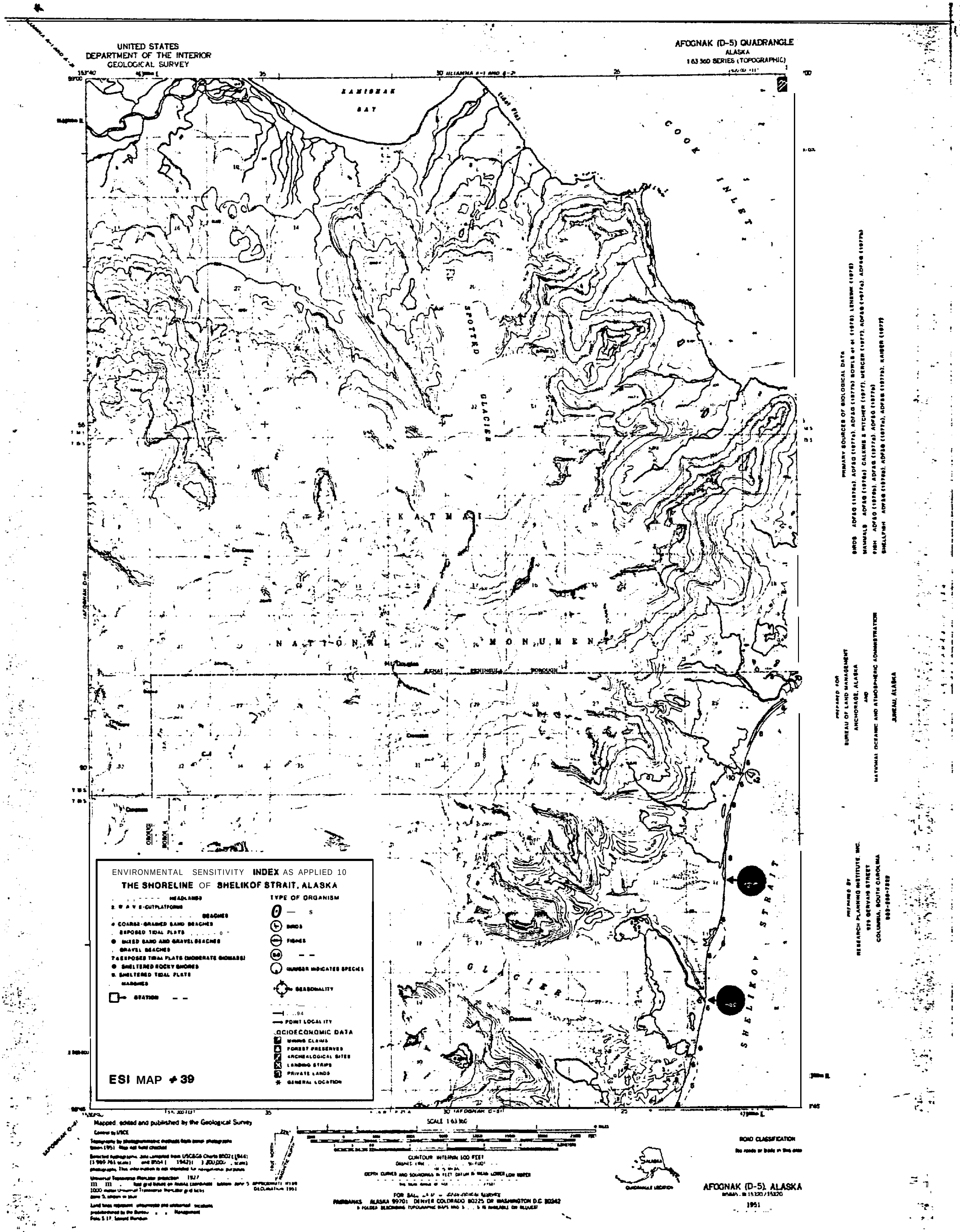
AFOGNAK (C-5) ALASKA
1951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ALASKA
1:63 360 SERIES (TOPOGRAPHIC)
KAMISHAK
BAY
COOK
INLET
SPOTTED
GLACIER
KATMAI
NATIONAL MONUMENT
Mt Douglas
KENAI PENINSULA BOROUGH
SHELIKOF STRAIT
ENVIRONMENTAL SENSITIVITY INDEX AS APPLIED TO
THE SHORELINE OF SHELIKOF STRAIT, ALASKA
TYPE OF ORGANISM
BIRDS
FISHES
NUMBER INDICATES SPECIES
SEASONALITY
POINT LOCALITY
SOCIOECONOMIC DATA
MINING CLAIMS
FOREST PRESERVES
ARCHEOLOGICAL SITES
LANDING STRIPS
PRIVATE LANDS
GENERAL LOCATION
ESI MAP # 39
PRIMARY SOURCES OF BIOLOGICAL DATA
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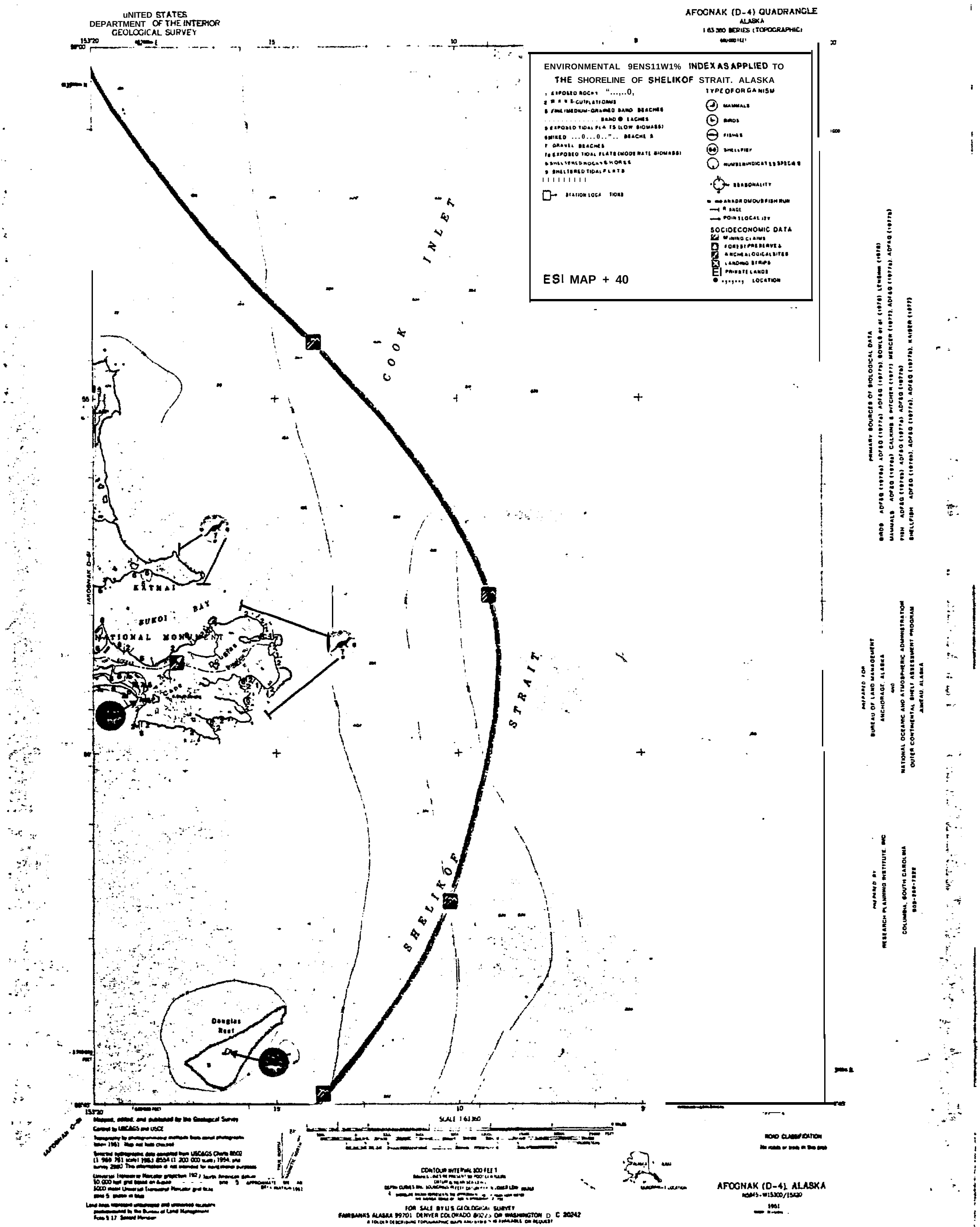
QUADRANGLE LOCATION
ALASKA
AFOGNAK (D-5), ALASKA
1951


UNITED STATES
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GEOLOGICAL SURVEY
AFOGNAK (D-4) QUADRANGLE
ALASKA
ENVIRONMENTAL 9ENS11W1% INDEX AS APPLIED TO
THE SHORELINE OF SHELIKOF STRAIT. ALASKA
TYPE OF ORGANISM
MAMMALS
BIRDS
FISHES
SHELLFISH
SEASONALITY
SOCIOECONOMIC DATA
ESI MAP + 40
COOK INLET
SHELIKOF STRAIT
KATMAI
NATIONAL MONUMENT
KUKAK BAY
Douglas Reef
PRIMARY SOURCES OF BIOLOGICAL DATA
PREPARED FOR
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ROAD CLASSIFICATION
AFOGNAK (D-4), ALASKA
1951